# DODGING BULLETS: THE THREAT OF SPACE DEBRIS TO U.S. NATIONAL SECURITY

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## ABSTRACT

DODGING BULLETS: THE THREAT OF SPACE DEBRIS TO U.S. NATIONAL SECURITY, by Susan Ireland, 132 pages.

With several hundreds of thousands space debris "bullets" orbiting the Earth, the U.S. Government enters a high risk environment whenever a satellite is launched into orbit. Because of the United States' dependence on space assets, the threat of space debris should be regarded as any other threat to national security interests. The current U.S. policy towards mitigating space debris will limit the amount of space debris created by the U.S. space industry. However, since there is no 'check and balance' approach or binding authority to ensure that other space faring nations or private industries follow the current *United Nations Space Debris Mitigation Guidelines*, there is a threat to U.S. national security.

The *United Nations Space Debris Mitigation Guidelines* are voluntary and lack the enforcement mechanisms to effectively ensure compliance across the international industry. A space debris mitigation compliance program within the international community would better protect U.S. national security interests in space. This thesis compares two international groups with compliance measures to explore the compliance framework and the effectiveness of the compliance programs on the impacted industry. The analysis resulted in the development of a recommended model for incorporating compliance measures for the *United Nations Space Debris Mitigation Guidelines*.

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Finally, I would like to send my love to my family. They sacrificed a year out of their lives so I could attend school in Kansas. It has made me truly appreciate that there really is no place like home.

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# ACRONYMS

| | |
|---|---|
| AIAA | American Institute for Aeronautics and Astronautics |
| ASAT | Anti-Satellite Weapon |
| COPUOS | Committee on the Peaceful Uses of Outer Space (United Nations) |
| DARPA | Defense Advanced Research Projects Agency |
| DOD | Department of Defense (United States) |
| FATF | Financial Action Task Force |
| FSRB | FATF-Style Regional Body |
| GAO | General Accounting Office |
| IADC | Inter-Agency Debris Coordinating Committee |
| NASA | National Aeronautics and Space Administration (United States) |
| SBSS | Space Based Space Surveillance System |
| UN | United Nations |

## ILLUSTRATIONS

# CHAPTER 1

# INTRODUCTION

Since 1957, when Russia launched the first satellite into space, the United States began to catalog all manmade objects orbiting the Earth. Dating back to the first satellite, Sputnik, the U.S. Space Surveillance Network catalog has a record of over 35,000 objects that have orbited, or are currently orbiting, the Earth. According to a recent 2009 request for information for orbital debris removal by the Defense Advanced Research Projects Agency (DARPA), 94 percent of the 20,000 cataloged objects remaining in orbit are non-functioning space debris. The 20,000 cataloged objects are just a drop in the bucket when compared to the hundreds of thousands of smaller objects that also pose a threat to the approximate 900 operational satellites, of which 437 belong to the United States, currently in orbit.[1] To fully frame the potential danger that the statistics from the DARPA report present, one must take into account the speed that the space debris, from the smallest paint chip to the largest defunct satellite, is traveling. The British Broadcasting Corporation makes the following comparison:

> Below altitudes of 2,000 km [low Earth orbit], the average relative impact speed is 36,000 kilometers per hour (21,600 miles per hour). At this speed . . . a 1 mm metal chip could do as much damage as a .22 caliber long rifle bullet . . . a pea-sized ball moving this fast is as dangerous as a 40 pound safe traveling at 60 miles per hour . . . a metal sphere the size of a tennis ball is as lethal as 25 sticks of dynamite.[2]

Combining the set of references from DARPA on the amount of debris with the references from the British Broadcasting Corporation on the speed of debris, it is easy to see that every satellite sent into space spends its lifespan in orbit dodging hundreds of thousands of bullets and several bundles of dynamite on every orbital pass.

With several hundreds of thousands space debris “bullets” orbiting the Earth, the U.S. Government enters a high risk environment whenever a satellite is launched into orbit. The stakes of space operations are high because building, launching and operating a network of satellites is a significant investment for any country that chooses to operate in the high risk environment where an accidental ‘fender bender’ could cause a catastrophic failure resulting in the loss of millions of dollars and years of productivity. According to a 2007 report from the International Security Advisory Board, “the United States relies on space for scientific, civil, military, and intelligence purposes more than any other nation, and its dependency is growing.”[3] There is a direct relationship between the increasing reliance on satellites to achieve security, economic growth, and prosperity through commercial and military uses and the increase of U.S. national security interests to maintain a functioning network of satellite systems.

Because of the United States’ dependence on space assets, the threat of space debris should be regarded as any other threat to national security. To date, the United States has only taken good housekeeping steps towards dealing with space debris, such as developing space debris mitigation policies, but housekeeping does not prevent the threat of debris created by others. The current U.S. policy towards mitigating space debris will limit the amount of space debris created by the U.S. space industry. However, since the United States does not operate alone in space, good housekeeping takes a community effort by all space faring nations to keep the space environment free from excessive amounts of debris. Since there is no ‘check and balance’ approach or binding authority to ensure that other space faring nations or private industries follow current United Nations’

debris mitigation guidelines, the creation of space debris will continue to pose a threat to U.S. national security interests in space.

## Background

Space debris has been a growing concern since mankind began launching spacecraft into orbit. With each launch, additional material has been added to the pool of space debris in orbit. Referencing the 4,700 pieces of space debris tracked by the Department of Defense's Space Surveillance Network in 1980, to the 19,000 pieces currently tracked, U.S. Air Force Lieutenant General Larry James, the commander of the U.S. Strategic Command's Joint Functional Component Command for Space, said, "in 29 years, the amount of space traffic has quadrupled."[4] Although the emerging statistics, such as the Department of Defense's debris tracking trends, indicate a growing threat, one would think that enforcing space debris mitigation rules would be in everyone's best interest; however, the current international solution has only been to publish a set of non-binding guidelines that list ideal practices for the industry.

Between 1967 and 1979, the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) passed one treaty, two agreements, and two conventions governing the use of space. The five accords incorporate the minimum amount of constraints in order to allow the maximum freedom of access to space for peaceful uses; therefore, there were few absolutes written into the internationally recognized treaty, agreements, and conventions. The objective to maintain maximum freedom of access to space has fostered a culture by several nations, including the United States, that less regulation is better. The mindset of less regulation equaling maximum freedom has made

implementing new United Nations' agreements very difficult, especially when the proposed new constraint could potentially make access to space more difficult.

The United Nations faces two primary obstacles that need to be overcome in order to effectively mitigate space debris on an international level. The first obstacle is the lack of a standard definition for 'space debris' and 'space objects' between the current space treaty, agreements, and conventions. The lack of an accepted definition blurs the lines for legal responsibility and accountability. The second obstacle is the United Nations' need for consensus by member states to pass an enforceable agreement. Member states often have conflicting national interests and are unable, or unwilling, to agree on the necessary binding terminology required for an internationally binding agreement. The two obstacles continue to hinder the adoption of an internationally binding space debris mitigation agreement, and by extension, fail to effectively mitigate space debris on an international level.

For decades, space debris has been acknowledged as a risk factor to space operations. The people and agencies concerned with the growing amount of space debris were primarily the owners and agencies that launched the expensive satellites and manned missions into space. Understanding the growing risks, some nations began to proactively take steps to reduce the creation of operational debris or protect assets from debris damage. However, since an internationally binding and enforceable agreement to mitigate space debris is lacking, space faring nations and private organizations are resigned to implement options that are currently not standardized across the international community. Three popular options have been to (1) set national laws or policies that may or may not be replicated in other launching territories, (2) increase protection of satellite

systems from space debris through design, and (3) enhance coordination and tracking capabilities of potential debris threats in orbit.

Because of the legal loopholes created by having separate national level policies, two negative hazards have been of growing concern within the international space community. The first concern is that international consortiums conducting international space operations in international waters may not be covered by any domestic policies and may complicate legal issues on responsibility, such as identifying who is the legally responsible launching state if a liabilities claim is presented. The second concern is that different debris mitigation standards may cause an imbalance in operational costs between entities in the industry that follow the guidelines and those who do not. Since implementing voluntary space debris mitigation techniques will often mean investing in additional overhead cost with equal or less productivity, there is no immediate economical benefit. Since space debris mitigation is seen as a long term investment, because creating less debris over time will allow for a safer space environment in the future, some in the space industry fear that, as spaceflight becomes less expensive, less reputable organizations will look only at immediate cost and will not comply with debris mitigation standards.

Whether through formal requirements or by voluntary action, national and private industry level debris mitigation standards can only meet limited success in protecting space assets from orbiting debris. Unlike an international agreement which would cover the entire industry, national level implementation becomes a piecemeal international approach. The piecemeal approach that leaves exploitable gaps as some space launching operators continue to create debris without constraint or fall outside of any domestic legal

boundary, such as international consortiums launching from international waters. Gaps in the national and private organizations' self-imposed debris mitigation programs have allowed inconsistencies to span across the international space industry. For example, one growing problem is the gap among various national-level debris tracking systems that may not communicate with other nation-state systems. Various tracking systems that do not share information can create gaps that allow space collisions to occur due to incomplete coverage by one system that could have been supplemented by the other or through failure to communicate conflicting orbital track information. In addition, an economic gap may form between satellite and launch platform developers who are required to implement national level mitigation policies and those that do not.

Until three recent debris creating events occurred, which brought the threat of space debris to the forefront of mainstream awareness, there were mixed opinions about the need to create more stringent, or internationally binding, debris mitigation measures. Starting in 2007, three incidents occurred in three consecutive years that changed the urgency towards dealing with space debris. The first incident was the decision by China to test an anti-satellite weapon on a defunct satellite orbiting in a heavily populated area of space. The second incident was the benchmark approach taken by the United States in 2008 to limit debris creation when an unresponsive satellite was destroyed because the uncontrolled reentry could release dangerous levels of hazardous fuel into Earth's atmosphere. The third incident occurred in 2009 when two satellites, Cosmos 2251 and Iridium 33, collided without warning. This was an unprecedented event that took the space community by surprise. Until 2007, space debris was generally considered, at best, an operational threat; however, since the three incidents occurred, the threat of space

debris has become an increasing strategic concern for the national security interests of the United States.

The impact of the recent debris creating events is evident when shown graphically. The Union of Concerned Scientists has charted the amount of space debris since the 1960s (see figure 1).[5] The spike in total space objects from the Chinese anti-satellite test shows the creation of a significant gap growing between operational spacecraft and fragmentation debris. The gap further expanded with the events of the Cosmos and Iridium collision. Also noted within the chart is a Russian rocket stage that exploded in February 2007 creating approximately 1,000 additional pieces of space debris.[6]

Nation states and space asset owners are no longer the only ones concerned for the growing threat of space debris. General public awareness has dramatically increased with incidents such as the three landmark debris creating events listed above. Increasingly, the public is reminded of the space debris threat when dramatic near misses with manned spacecraft make headlines news. For example, in September 2009 the mission of the Space Shuttle Discovery was overshadowed by news reports about the National Aeronautics and Space Administration (NASA) debating if the shuttle would need to maneuver the International Space Station out of the way of a piece of space debris (a spent Arian 5 rocket stage). Then only eight days later NASA made news again when the Discovery was actually forced to fire the shuttle's thrusters in order to dodge a piece of its own debris before maneuvering to return safely to Earth.[7] Perhaps due to the two near brushes with debris, or perhaps just coincidental timing, the release of the DARPA request for information on how to clean up and reduce space debris just days

after the Discovery's safe landing was yet another example of the U.S. Government's acknowledgement that space debris is a growing concern.

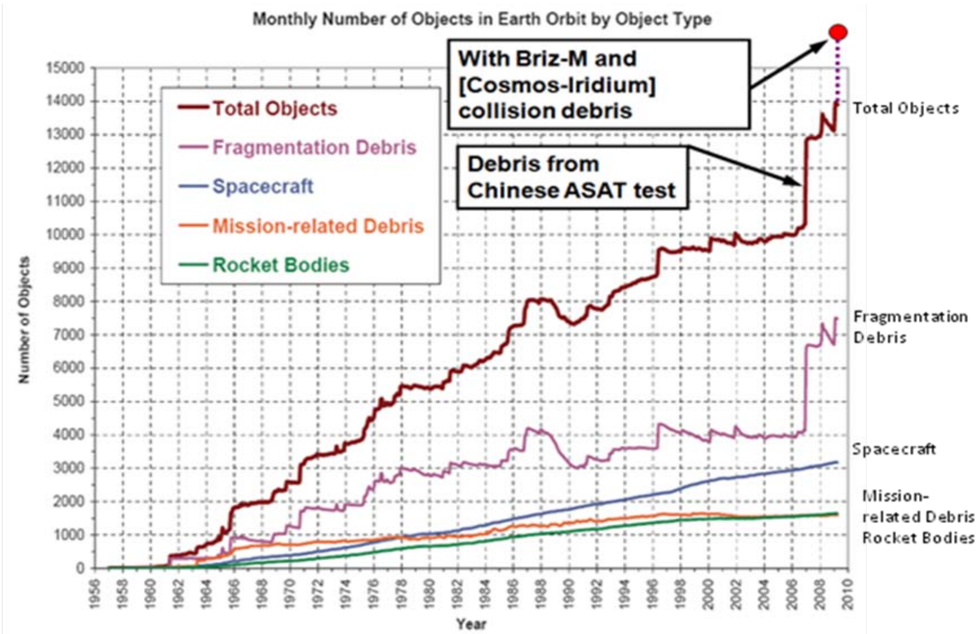


Figure 1. Number of Space Objects by Object Type.
*Source*: Union of Concerned Scientists, "Monthly Number of Objects in Earth Orbit by Object Type," www.ucsusa.org/assets/documents/nwgs/Debris-growth-graph-5-18-09.ppt (accessed 18 January 2010).

## Thesis

The U.S. policy towards mitigating space debris will limit the amount of space debris created by the U.S. space industry. However, since there is no 'check and balance' approach or binding authority to ensure that other space faring states or private industries follow current United Nations' guidelines, space debris poses a significant threat to U.S. national security interests. A space debris mitigation compliance program within the international community would better protect U.S. national security interests in space.

## Primary Research Question

National infrastructures and military operations of the United States are ever more reliant on services that both commercial and military satellites provide. The increase in dependence on space operations means that the safety and security of U.S. assets in space are becoming more indispensable. Michael B. Donley, Secretary of the Air Force, said in a keynote speech on 21 November 2008 that "commercial and national security reliance on these space-based capabilities is interdependent. Commerce depends on reliable weather information, and precision navigation and timing. And the national security community uses commercially-available SATCOM and imagery."[8]

With gaps in the international debris mitigation framework, U.S. national security interests are not sufficiently protected from the threat of space debris. The primary research question is: what compliance measures could be taken to strengthen mitigation guidelines and better protect U.S. space assets from space debris? In order to answer the primary research question, the following three questions must also be addressed: (1) what is the current space debris environment (2) what is the connection between space debris and U.S. national interests and (3) what formal and informal legal structures govern the mitigation of space debris? From the three primary questions, analysis will be conducted to determine if a compliance program could be implemented to strengthen current *United Nations Space Debris Mitigation Guidelines*.

## Limitations and Delimitations

This paper will focus primarily on man-made space debris. When possible, a distinction will be made between man-made and natural space debris, such as comets and asteroids; however, statistical data does not always distinguish between man-made and

natural particles. Another limitation is the accuracy of space debris data. Unclassified material will be used for analysis; however, it should be noted that specific details on the current amount and size of tracked space debris is often classified.

Although several countries are studying space debris, the research for this paper has been limited to information written in English. Therefore, the Peoples Republic of China may have a different point of view about the effects of its anti-satellite weapon test which will not be reflected in this research. National policies, international practices, and scientific data about the current space debris environment collected from multiple sources (United States, United Kingdom, Australia, European Community, and others) has produced sufficient amounts of material to analyze in order to determine the threat to U.S. national security interests. Primary and secondary document sources were used to research the answers to the questions posed above.

## Significance

Debris from the accidental collision between a Russian and American satellite, and the intentional satellite destructions by China and the United States marks the three largest, and most recent, incidents in history creating space debris. The evidence that each of the three events occurred within the last three years, from 2007 to 2009, indicates a growing danger for future incidents. The fact that the three incidents did not violate any laws points to a legal gap that could allow additional intentionally destructive debris creating events to occur in the future without penalty. Without strengthening international standards to mitigate space debris by adding provisions for enforcing compliance, U.S. space assets will remain at risk of destruction, which in turn weakens the space based systems underpinning U.S. national security interests. The following chapters will

provide the details to the research and analysis conducted to answer the primary question: what compliance measures could be taken to strengthen mitigation guidelines and better protect space assets from space debris?

## Overview

Chapter 2 outlines a literature review of the three secondary questions: (1) what is the current space debris environment (2) what is the connection between space debris and U.S. national interests and (3) what formal and informal legal structures govern the mitigation of space debris? The current space debris environment, question one, is described using three recent events that have significantly altered the debate on debris mitigation compliance. The connection between space debris and U.S. national interests, question two, has three subcomponent topics. The first is a review of the United States' reliance on space based operations, the second is the definition of national security and the third is the current methods used to protect space assets from space debris. The formal and informal structures governing the mitigation of space debris, question three, was also broken down into two subcomponent topics. The first was a review of weaknesses in the current international and national legal frameworks governing space debris and second was to review how effective the debris mitigation framework has been.

Chapter 3 describes the research methodology used to conduct the study to answer the primary research question: what compliance measures could be taken to strengthen mitigation guidelines and better protect space assets from space debris? A literature review was conducted and two case studies were analyzed. Qualitative information gathered from two case studies of international organizations with international standards was used to compare and contrast compliance methods. The case studies were used to

determine if compliance with space debris mitigation guidelines could be implemented and if the compliance methods could be effective.

Chapter 4 summarizes the findings of the research. Two case studies were analyzed. The first case study compares the compliance methods of the United Nations Social, Humanitarian and Cultural Affairs Committee, a group that focuses on standardizing human rights issues. The second case study compares the compliance methods of the Financial Action Task Force, an international organization that focuses on standardizing anti-money laundering and counter-terrorist financing standards. The case studies were evaluated on the type and effectiveness of compliance measures. Analysis conducted on the two case studies was used to determine if a similar compliance program is feasible for the *United Nations Space Debris Mitigation Guidelines*.

Chapter 5 provides a conclusion based on the findings of chapter 4. Beyond the legal need of translating the United Nations' guidelines on space debris mitigation into a formal, binding, and enforceable agreement, compliance methods should be established to serve as a stop-gap solution that improves conformity with the international standards. In addition to the conclusions, a set of recommendations are offered to address the problem of international compliance with the *United Nations Space Debris Mitigation Guidelines* in order to better protect U.S. national security interests. The Inter-Agency Space Debris Coordination Committee (IADC) focuses on operational issues of space debris and could be expanded to include a national-level self-reporting compliance program that is verified through the use of peer monitors.

## Summary

The threat of space debris to current operations is a growing concern in the space industry. The United Nations has promulgated international treaties and guidelines that member nations have agreed upon; however, to date, space debris mitigation is an unbinding set of guidelines. Although, the United States created a framework of space operation policies that include the mitigation of space debris, national level policies do not protect national assets in space from debris caused by others. The lack of legal power to enforce international guidelines creates loopholes that could be exploited by deliberate or accidental means, and result in hazardous conditions caused by space debris. It is important to enforce compliance with international mitigation guidelines to reduce the growth of orbital debris and begin, if possible, to diminish current amounts in order to keep space debris from expanding exponentially beyond acceptable risk levels. The findings and recommendations of this paper are meant to address the growing threat of space debris and help protect the vital service performed by functioning satellites.

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[1]Defense Advanced Research Projects Agency, Solicitation Number DARPA-SN-09-68, "Defense Advanced Research Projects Agency Orbital Debris Removal Request for Information," 17 September 2009, https://www.fbo.gov/index?s=opportunity&mode=form&id=a55fd6e5721284ee7df2068d2b300b5f&tab=core&_cview=0&cck=1&au=&ck= (accessed 21 September 2009).

[2]British Broadcasting Corporation Science and Nature: Space, "Space Junk," 10 September 2009, http://www.bbc.co.uk/science/space/solarsystem/earth/spacejunk.shtml (accessed 10 September 2009).

[3]International Security Advisory Board, "Report on US Space Policy," 25 April 2007, http://www.state.gov/documents/organization/85263.pdf (accessed 12 October 2009).

[4]Tariq Malik, "Space Junk Around Earth on the Rise, Experts Say," 29 April 2009, http://www.space.com/news/090429-space-debris-safety.html (accessed 8 September 2009).

[5]Union of Concerned Scientists, “Monthly Number of Objects in Earth Orbit by Object Type,” www.ucsusa.org/assets/documents/nwgs/Debris-growth-graph-5-18-09.ppt (accessed 18 January 2010).

[6]Ibid.

[7]Chris Dolmetsch, “Space Shuttle Discovery Fires Engines to Dodge Debris (Update 1),” 20 September 2009, http://bloomberg.com/apps/news?pid=conewsstory&tkr=BA:US&sid=alp7ZqveJ9Yk (accessed 22 September 2009).

[8]Michael Donley, “The Interagency Domain of National Security Space” (A keynote address as prepared for delivery to the Air Force Association's Global Warfare Symposium, Los Angeles, 21 November 2008), http://www.af.mil/information/speeches/speech.asp?id=434 (accessed 12 October 2009).

# CHAPTER 2

# LITERATURE REVIEW

Man has been generating space debris with every rocket launch into space. Much of that space debris continues to orbit the Earth. Without intervention, the space environment will soon reach a critical tipping point where space debris poses to high of a risk to operate in densely populated orbits. Since the United States does not operate alone in space, a space debris mitigation compliance program within the international community would better protect U.S. national security interests in space. This chapter will provide details on the research conducted to answer three secondary questions: (1) what is the current space debris environment, (2) what is the connection between space debris and U.S. national interests, and (3) what formal and informal legal structures govern the mitigation of space debris? The literature review has been categorized by the secondary question that the publications answer.

## What is the Current Space Debris Environment?

The current space debris environment is described using the three recent events that have significantly altered the debate on debris mitigation compliance. Starting in 2007, three incidents occurred in three consecutive years. The first incident was the decision by China to test an anti-satellite weapon on a defunct satellite orbiting in a heavily populated area of space. Second was the benchmark approach taken by the United States in 2008 to limit debris creation when an unresponsive satellite was destroyed because the uncontrolled reentry could release dangerous levels of hazardous fuel into Earth's atmosphere. The third event occurred in 2009 when a defunct Russian

satellite collided with an operational American satellite without warning. The collision was an unprecedented event that took the space faring community by surprise.

## The Chinese Destruction of Feng Yun-1C

The first major space debris occurrence happened on 11 January 2007, when the Peoples Republic of China successfully used an anti-satellite weapon against the defunct Feng Yun-1C weather satellite. The satellite was retired in 2004 after being launched into a sun-synchronous orbit on 10 May 1999.[1] The sun-synchronous orbit placed the Feng Yun-1C on a north-to-south-pole track that allowed the satellite to pass "over the same part of the Earth at roughly the same local time each day"[2] in order to track meteorological conditions. When the satellite passed over the Chinese Sichuan province, China launched the test anti-satellite missile. The impact caused the Feng Yun-1C to splinter into approximately 20,000 to 40,000 pieces larger than one centimeter of which 2,200[3] to 2,500[4] pieces were larger than 10 centimeters. Of the untrackable fragments, experts estimate that the anti-satellite test produced approximately two million[5] pieces smaller than one centimeter. According to NASA, "the debris cloud created by a successful test of the Chinese anti-satellite (ASAT) system . . . represents the single worst contamination of low Earth orbit (LEO) during the past 50 years."[6] By the end of 2007, "the U.S. Space Surveillance Network had officially cataloged 2,317 debris, of which only 22 (less than 1%) had reentered the atmosphere."[7]

The amount of debris created from the anti-satellite test coupled with China's lack of communication about its intent to destroy a satellite caused a ripple effect of concern over the primary and secondary effects of space debris. The outcry from the space industry was not so much because of concern over China's ability to blow up one of its

own satellites, as much as it was because of the danger the fragmentation posed to orbiting systems in nearby altitudes. At the altitude of 863 kilometers, the debris could threaten a commonly used area of space.[8] The 20,000 to 40,000 pieces resulted in a 20 percent increase[9] in the number of objects too small to track and too large to protect with shielding in low Earth orbit. Although a majority of the debris continues to orbit near the original 800 kilometer altitude because it was in a sun-synchronous orbit; some fragments have reached altitudes up to 3,500 kilometers (medium Earth orbit).[10]

A study conducted in 2009 of China's anti-satellite activities found that over 50, of the approximate 920 operational satellites currently in orbit around the Earth,[11] were near the altitude of debris from the Feng Yun-1C.[12] Of the 50 satellites, 16 are in such proximity that if a sizeable conjunction occurs, "[it] could have a dramatic cascading effect, leading to uncontrollable and/or inoperable satellites threatening other satellites in nearby orbits."[13] Although China endangered two other operational Feng Yun satellites, nearly half (seven) of the 16 threatened satellites belong to the United States. Five of the seven U.S. satellites are military owned and the remaining two are government owned. A complete list of the threatened satellites is found in Appendix A.

International discussions to draft a formal treaty on space debris mitigation were renewed after China's destruction of the Feng Yun-1C. Part of the reason for the renewed interest in a debris mitigation agreement was because the altitude of the Feng Yun-1C's event created a debris field comprised of large debris fragments (greater than 10 centimeters), that will take over a century to degrade and reenter Earth's orbit (see figure 2), and smaller fragments that will stay in orbit for millennia.[14] Because the scope of debris field posed a significant threat to the international space faring community, the

danger spurred a renewed interest in formalizing debris mitigation laws. Other discussions focused on operational issues to determine if the debris creation event would threaten any of the space operations occurring at the time.

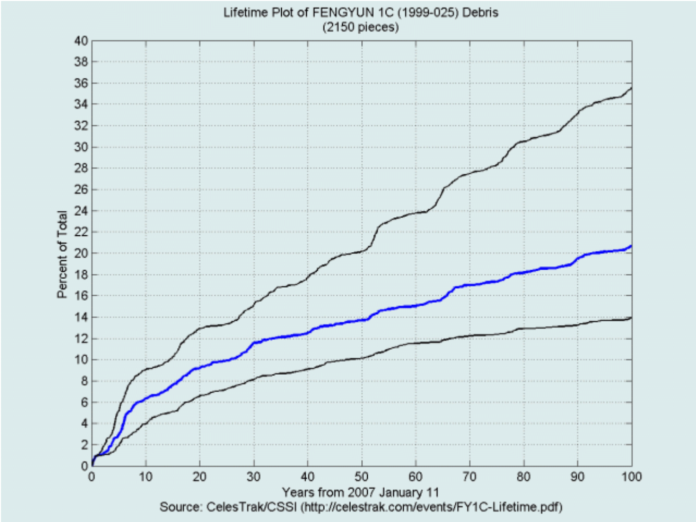


Figure 2. Lifetime Plot of Feng Yun-1C Debris
*Source*: CelesTrak/CSSI, "Lifetime Plot of Feng Yun-1C Debris," http://celestrak.com/events/FY1C-Lifetime.pdf) (accessed 16 March 2010). Middle (blue) line indicates the average predicted years for debris to degrade into Earth's atmosphere, upper and lower (black) lines indicate high and low year predictions.

Since the Chinese destroyed one of their own satellites over Chinese territory, the Feng Yun-1C event did not break any international treaty or space laws. There is the potential that damage to another satellite may evoke the Liabilities Convention; however, as time continues and the Feng Yun-1C's debris cloud merges with other space debris in orbit, any future damage to surrounding satellites will be difficult to trace specifically back to the Chinese anti-satellite test. Proving the damage was linked to the Feng Yun-1C incident and not some other wayward piece of space junk will be nearly impossible.

Although legal discussions about the Chinese anti-satellite test surrounded issues of how to prevent future intentional satellite destructions from causing massive long-lasting debris clouds, no satisfactory solution ever came to fruition except to publish a the set of voluntary debris mitigation guidelines. Because the guidelines lack compliance measures to mitigate the creation of space debris according to international standards, had the Chinese conducted the anti-satellite test after the guidelines were published, there would not have been any change to the legal standing (no treaty or convention was broken).

## The United States Destruction of NROL-21

The second event occurred on 20 February 2008, when the United States destroyed the NROL-21(USA 193) National Reconnaissance Office satellite using a modified conventional missile. Shortly after reaching orbit, ground stations lost communication with the satellite. Despite several attempts to reestablish links, the satellite was declared a loss in August 2007.[15] Unable to communicate with NROL-21, scientists could not maintain the satellite's 250 kilometer altitude. Estimates showed the satellite's orbit would degrade and reenter Earth's atmosphere within seven months. The inability to control the reentry point of the satellite posed a significant threat because of the nearly full onboard tanks of hazardous fuels, hydrazine and beryllium. Therefore, the decision was made to destroy the satellite to prevent hazardous materials from reaching the ground.

When the U.S. Navy launched the missile to destroy the satellite, the impact caused NROL-21 to break into approximately 360 large (greater than 10 centimeters) pieces. On 25 February 2008, just five days after the event, the 30th Space Wing at Vandenberg Air Force Base reported that, "the Joint Functional Component Command

for Space Joint Space Operations Center here is tracking less than 3,000 pieces of debris [for this event]. . . the vast majority of debris has already reentered or will shortly reenter the Earth's atmosphere in the coming days and weeks."[16] Over 95 percent of the debris reentered Earth's atmosphere within 60 days (see figure 3).

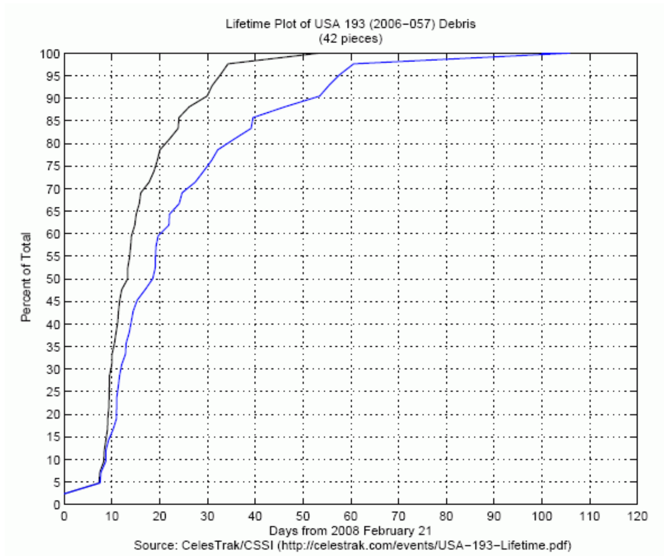


Figure 3. Lifetime Plot of USA-193 (NROL-21) Debris
*Source*: CelesTrak/CSSI, "Lifetime Plot of USA 193 Debris," http://celestrak.com/events/USA-193-Lifetime.pdf (accessed 16 March 2010). Blue line indicates the lower and black line indicates the upper prediction limit for number of days for debris to degrade into Earth's atmosphere.

Regardless of any technical or political reason to destroy the satellite, the event had a significant impact on current space debris discussions about national and international policies. Similar to the Chinese Feng Yun-1C event, the destruction of the NROL-21 did not break any international treaties or space laws since the U.S. satellite was destroyed by the United States. The major difference was that the United States put the world on alert to the pending space debris threat and attempted to mitigate the amount

of debris maintained in orbit. The total amount of debris created from this event may never be completely known since tracked debris is only a small subset of the total number of particles. However, the precedent set by the United States prevailed in establishing a benchmark of acceptable measures to be taken when an intentional debris causing event is necessary.

### The Collision between Cosmos 2251 and Iridium 33

The third event occurred on 10 February 2009 when a collision occurred between Cosmos 2251, a defunct Russian communications satellite and Iridium 33, an operating American communications satellite. Similar to most space objects, the defunct Cosmos 2251 orbit was not continuously tracked but merely checked periodically for position updates; therefore, the collision came as a complete surprise to both Russia and the United States. Although the two satellites were known to orbit in close proximity, the risk of a conjunction was low. Estimated odds of a conjunction similar to the Cosmos and Iridium collision placed the probability as one chance in six million on any given orbital pass.[17] Discussing the Cosmos and Iridium collision, Nicholas Johnson, Chief Scientist of the NASA Orbit Debris Program Office at the Johnson Space Center in Houston, said, “the U.S. Space Surveillance Network has identified more than 1,800 [larger than 10 centimeters] new debris objects,”[18] created from the Cosmos and Iridium collision. An additional 50,000 pieces are estimated to be between one and ten centimeters. “For the Iridium 33 debris, over half of it is beyond the 100-year contour (see figure 4). For the Cosmos 2251 debris, several dozen pieces (beyond those which have already decayed) should reenter in the next couple of years, but significant numbers will likely remain in orbit 25-50 years (see figure 5) from now.”[19] There is a difference between the two

satellite debris degradation timelines because the Iridium 33 debris was pushed primarily into a higher orbit while the Cosmos 2251 debris was pushed lower by the collision. To date, the *Liability Convention* has not been evoked by either party and the incident has been considered as an inevitable consequence to operating in the space environment.

Mr. Johnson further stated that, "never before have two intact satellites crashed into one another by accident."[20] The convergence of the two satellites was a paradigm event for assessing the threat of space debris created by non-intentional satellite collisions. The fact that the two satellites collided without any prior warning indicates there are gaps in the detection and tracking system that leave U.S. national security interests vulnerable to disruption by space debris.

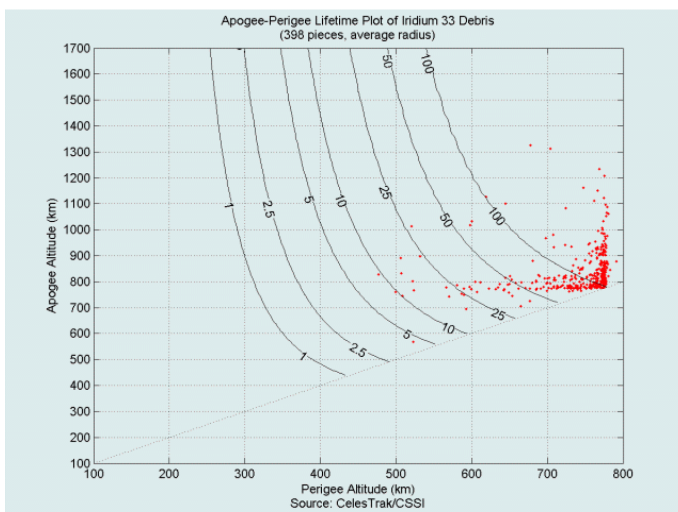


Figure 4. Lifetime Plot of Iridium 33 Debris
*Source*: CelesTrak/CSSI, "Apogee-Perigee Lifetime Plot of Iridium 33 Debris," http://celestrak.com/events/collision/ (accessed 16 March 2010).

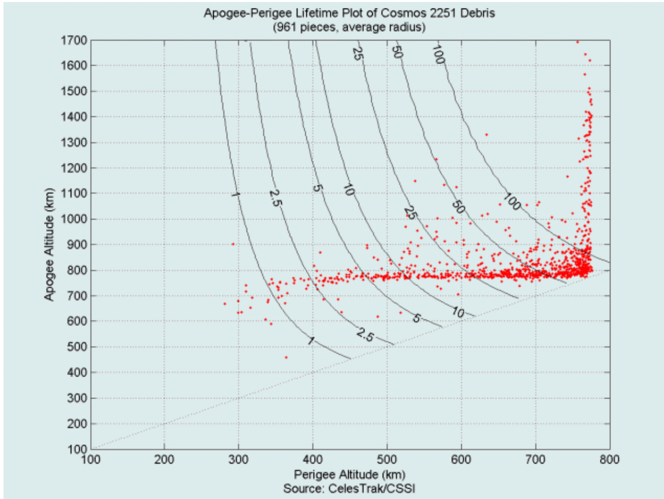


Figure 5. Lifetime Plot of Cosmos 2251 Debris
*Source*: CelesTrak/CSSI, “Apogee-Perigee Lifetime Plot of Cosmos 2251 Debris,” http://celestrak.com/events/collision/ (accessed 16 March 2010).

What are the Connections between Space Debris and U.S. National Interests?

Three aspects of U.S. national security need to be reviewed in order to answer the question about the connection between space debris and U.S. national security. The first aspect is to determine: what is the definition of national security. The second aspect is to determine: how reliant are U.S. national security interests on space based operations. The third aspect is to determine: how the United States is protecting space assets from space debris threats. Based on an unclassified review of literature about U.S. national security and the current debris environment in space, the question regarding the connection between space debris and U.S. national interests can be answered.

## What is the Definition of National Security?

Robert Ebel, Director for Energy and National Security, speaking before the U.S. Senate Committee on Governmental Affairs, stated that "George Kennan [historian and former U.S. Ambassador to the Soviet Union] has offered perhaps the least complicated definition [of national security]: "the continued ability of this country to pursue its internal life without serious interference . . . and the greater the dependence, the greater the prospect for interference."[21] Therefore based on Messrs. Ebel and Kennan's definitions, national security interests of space operations can range far beyond the classified or military systems to include all space based systems that improve aspects of everyday life in the United States. The more reliant society becomes on any technology, the more the asset becomes a national security interest. Because of increasing societal reliance, strategic principles shaping national security policies are increasingly based on protecting commercial and general use satellites. For example, "security concerns encroached on the use of global utilities when the European Union agreed with the U.S. National Oceanic and Atmospheric Administration (NOAA) to create a "data denial list" restricting certain agencies from accessing weather data from the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)."[22] Increasingly, general utility satellites, such as communication, navigation, weather, and search and rescue systems fall into the category of significant use for civil and military purposes for security, defense, economic growth, and commerce; therefore, nearly all space based systems have become an important national security interest to the United States.

## How Reliant is U.S. National Security on Space Based Operations?

Many reports have proven that the United States is more dependent on space than any other nation.[23] *Global Cooperation: Challenges and Opportunities in the Twenty-First Century*, published in 2006, describe a nation's need for using space technologies as a principle asset for leading in contemporary and global affairs. "From accurate weather forecasting and news to strategic resource, environmental and military planning – the capacity provided by space technology is increasingly available at some level to all societies, making its impact both more profound and accepted as yet another indispensable element of modernity."[24] Space systems are often the unnamed means working in the background that help maintain the economy and security of the United States.

Based on the definition of national security, and the intermingled use of commercial, military and national security data gathering systems, it is impossible to separate satellite services between purely private, public, or military use. For example, the private sector has actively pursued means to achieve high-resolution satellite imagery, previously a capability that was only available on military platforms, for projects such as urban planning, insurance assessments, and navigational maps. Because the private sector was able to successfully develop enhanced resolution capabilities and operate newer platforms, the military has increasingly incorporated commercial satellite imagery into mission planning and execution[25] saving the military significant costs by alleviating the need to operate dual systems.

Defense and intelligence agencies are active users of commercial satellites to fulfill communication and imaging requirements.

> The U.S. Department of Defense gained substantial experience with the use of [the commercial] Landsat's multi-spectral imagery during the 1991 Gulf War and began to find the information useful for creating wide area maps for operational support. Landsat data proved at times more versatile than military or intelligence imagery that provided high resolution in the optical range, but had very narrow fields of view. Landsat data could be combined with other available satellite images such as France's *Systeme Probatoire d'Observation de la Terre* (SPOT) [a 1986 system capable of 10-meter resolution satellite imagery, three-times that available from Landsat] for lower cost, and could be unclassified for wider dissemination.[26]

Similarly, commercial imaging satellites were used in conjunction with National Reconnaissance Office systems during Hurricane Katrina in 2005 and for the 2007 disaster response to wildfires in California, where unclassified information could be shared among several agencies and organizations quickly.[27] Beyond the dual national security and commercial roles of imaging and communication satellites, the Global Positioning System has followed a similar migration. Originally used for military support to track submarines then later adapted to provide precise coordinates of targets on the battlefield, Global Positioning System use has now expanded to help farmers map fields to grow more food, increased the precision of aviation navigation, created efficient systems to track and transport cargo, and increase public safety when using location information from cell phones or car systems.

Due to the co-mingling of commercial and military uses for satellites it is nearly impossible to deny access to space for certain purpose, such as covert hostile intentions, because the purposes and capabilities are interwoven. According to Mr. Scott Large, Director for the National Reconnaissance Office, "as a result . . . America's concept of national security space no longer encompasses only classified and unclassified DoD [Department of Defense] and Intelligence Community space systems; it includes all forms of space systems."[28] Any further considerations on U.S. national security interests

to protect assets in outer space has to deal with the co-mingling of private, public and military uses of any space based operating system.

Protection Through a Stronger Stance (Force)

The growing recognition of the Unite States' reliance on space operations and the increasing national security interest in protecting assets and access to space has been highlighted in the *2007 Space Security Report* on international trends and developments.

> Fueled by the technological revolution in military affairs, the military doctrine of a growing number of actors (led by China, Russia, the U.S., and key European states), increasingly emphasizes the use of space systems to support national security. Dependence on these systems has led several states to view space assets as critical national security infrastructures. U.S. military space doctrine has also begun to focus on the need to ensure U.S. freedom of action in space, through the use, when necessary, of "counterspace operations" that prevent adversaries from accessing space.[29]

Although the United States, like other space faring nations, subscribe to the belief that space is to be used for cooperative and peaceful purposes; that belief is constrained when national security interests are at stake. "The US released an unclassified version of a new National Space Policy [in 2006] similar to the 1996 version but with notable emphasis on US freedom of action in space and opposition to new legal regimes or other restrictions on US access to, or use of, space."[30]

The International Security Advisory Board (ISAB) *2007 Report on U.S. Space Policy* which was written soon after China's anti-satellite test, urges an even stronger stance on American space security policy.

> Threats to U.S. space assets, both from the ground and in space, are rapidly growing quantitatively and qualitatively. The United States does not have the luxury of assuming that its space assets will be available whenever needed. . . . Understanding and responding to threats to civil, commercial, and national security space assets is a vital national interest of the United States.

> A number of states are developing a variety of capabilities that will intentionally or unintentionally place at risk the space system operated and used by the United States. . . . The Chinese ASAT direct ascent test should be a wake up call for the United States. . . . Many of our space based assets serve both civilian and military users. Their destruction, or even the threat of their destruction, would have devastating economic and military implications. Threats, disruption, or damage to commercial satellite systems would wreak havoc on the U.S. and global economy.[31]

The ISAB *2007 Report on U.S. Space Policy* emphasizes the right of the United States to maintain freedom of action in space and opposes any proposed requirements at the United Nations COPUOS or elsewhere that would restrict U.S. access or use of space for peaceful or national security reasons.[32]

Because of the growing reliance on space systems and the need to maintain freedom of access to space, the need to defend assets has changed in recent years from an implied requirement to one that is specifically outlined in space policy. What is not sufficiently addressed in the ISAB *2007 Report on U.S. Space Policy* is how an increased stance to conduct counter-space operations, such as destroying threats in space, could adversely affect the levels of space debris by creating an exponential amount of additional debris. The ability to maintain freedom of access to space by force against ground-based systems or by non-kinetic space-based actions may be a viable solution; however the ability to maintain freedom of access by kinetic actions in space has to be balanced with maintaining an environment free of debris so that the orbits stay operationally viable. Therefore, debris mitigation must continue to be a core factor when shaping future space policies for protecting space assets from threats.

Protection Through Design

One way the United States is trying to protect national security interests in space is through a better tracking system for space debris. The U.S. Space Surveillance (SBSS) system, scheduled to launch in 2010, will be a “constellation of satellites that will detect and track orbiting space objects, including potential threats to our space assets and orbital debris. The Department of Defense will use data generated by the SBSS system to support military operations.”[33] In addition, the Air Force is leading the Talon Spectrum Red Cloud program, an “effort to load unique data directly into the catalog of orbiting space objects that the Joint Space Operations Center (JSpOC) maintains. Currently, the catalog only receives data from the sensors that are officially part of the space surveillance network.”[34]

America’s space tracking capabilities will be enhanced through programs like the SBSS system, which will improve the United State’s ability to detect space debris, and the Talon Spectrum Red Cloud program, which will allow non-traditional sensor data to reach the space catalog, thereby increasing situational awareness. However, tracking space debris is only addressing one symptom to the underlying problem of the continued creation of space debris. The 2007 ISAB report, as with other literature reviewed for this thesis, indicates a need to protect U.S. assets from the threats of space debris, but to date, no significant steps have been taken on the international level to establish compliance controls for the *United Nations Space Debris Mitigation Guidelines*.

## Is the United States Protected from Future Space Debris Threats?

To determine if U.S. assets are protected against space debris, a search of literature indicates that although shielding is available, the amount of shielding is a 'risk and weight versus benefit' decision space system developers. The 1997 General Accounting Office (GAO) report on space surveillance states that portions of the space station, a space asset of U.S. national security interest, has shielding that provides protection against objects smaller than one centimeter; however, NASA

> concluded that shielding against larger objects would be too costly. . . . The National Research Council report mentioned that debris from about 0.5 to 20 centimeters in diameter was of most concern to the space station because, within this range, the debris may be too large to shield against and too small to (currently) track and avoid.[35]

NASA relies on the Department of Defense (DOD) tracking system to determine when the potential risk of collisions with debris has exceeded safety parameters. During times of high risk, NASA will decide to move the shuttle or use the shuttle to move the space station out of danger from space debris. However, there are occasions when greater risk is accepted and the shuttle has not been maneuvered to avoid a possible collision with debris "because of concern for interference with the primary mission objective . . . [such as] microgravity experiments."[36]

Whether discussing manned or unmanned operations, the risk of damage versus the benefit of accomplishing the mission must be weighed by the operating organization. Since better situational awareness would allow NASA to make better decisions regarding the space environment and the actual risk, there has been a growing need to improve the DOD's detection and tracking systems. The GAO report on space surveillance said that NASA will require DOD to "detect, track, and catalog objects as small as 1 centimeter"

by 2002-2003 when the space station was estimated to be complete; however, the DOD stated that "achieving the capability . . . would be technically challenging."[37] To date, the full implementation of detecting, tracking and cataloging objects less than 10 centimeters has not been completed. The literature review reveals that gaps in the tracking system continue to place U.S. space assets and national security interests at risk.

The GAO report on space surveillance touches on one of the fundamental problems facing the space industry, which is the infeasibility to fully protect U.S. assets from the current amounts of space debris through design or maneuverability due to the cost and weight involved. Increased fuel for extra maneuverability is not the optimal solution when platforms for experiments cannot be disturbed or mission critical operations are required. Additional shielding is not the optimal solution to protect assets from larger debris impacts because the weight of shielding becomes cost prohibitive for debris larger than one centimeter. Therefore, the solution might not be additional shielding or maneuverability, but in better compliance or regulation to mitigate space debris.

## What Formal and Informal Frameworks Govern the Mitigation of Space Debris?

In order to answer the question about formal and informal structures governing the mitigation of space debris, two aspects will be reviewed in current literature. The first aspect is to answer the question: are there weaknesses in the current legal frameworks governing space debris and the second aspect is to answer the question: how effective are the formal and informal space debris mitigation frameworks? There were a sufficient number of books, studies and assessments written to conduct a literature review on the

two aspects of formal and informal frameworks governing space debris to answer the secondary question.

## Are There Weaknesses in the Current Legal Frameworks Governing Space Debris?

To determine if there are weaknesses in the current legal frameworks governing space debris, a literature review was conducted. The legal frameworks governing space debris were categorized into two segments (1) international laws, policies and agreements; and (2) U.S. law and domestic policies governing space debris. While international and domestic laws and policies are formal frameworks governing space activities, general accepted practices are a type of informal framework and are included in the section on space debris mitigation effectiveness.

### International: United Nations Space Treaty, Conventions, and Agreements

The United Nations COPUOS was established in 1958. The committee is the "only international forum for the development of international space law."[38] One treaty two agreements and two conventions, equally enforceable under international law, were promulgated between 1967 through 1979 to address: principles governing activities in outer space, the rescue of astronauts, liability for damages caused by space objects, the registration of items launched into space, and principles governing activities on the moon and other celestial bodies. The committee operates on the principle of consensus, therefore, as membership increases, the diversifications in opinions also increases. Appendix B contains the members of the COPUOS as of 2010 and the glossary section of this paper provides the distinctions between types of United Nations' agreements. Since the last convention passed in 1979, the Committee has only been able to produce

guidelines and principles, such as debris mitigation, that are not as durable or binding as conventions and are, therefore, unenforceable. The inability to enforce debris mitigation guidelines leaves a gap in efforts to minimize the main source of damage in space. Liability for damage caused by orbiting debris can often be difficult to determine; therefore, bolstering the debris mitigation guidelines would help supplement the Liability Convention by adding preventative measures in addition to the untested reactive recourse available through the compensation after damage occurs in space.

The United Nations' COPUOS agreements do not address the mitigation or control of space debris specifically; however, three of the five agreements govern activities and influence policies of signatory nation states that relate to space debris issues. The three agreements are: *The 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty); the 1972 Convention on International Liability for Damage Caused by Space Debris (Liabilities Convention);* and *the 1975 Convention on Registration of Objects Launched into Outer Space (Registration Convention). The Outer Space Treaty* binds member nations to the peaceful use of space, bans nuclear weapons in space, and holds countries responsible for their activities in space. *The Liabilities Convention* holds nations accountable for any damage caused by the space objects it owns. *The Registration Convention* obligates nations with monitoring facilities to track and identify objects in space.

Interpreting the legal application of the treaty and conventions for issues involving space debris is still unclear for several reasons. First, legal interpretation of the agreements is difficult due to the lack of official definitions between "space debris" and

"space objects."[39] For the purposes of the *United Nations' Liability Convention*, the term space object means "component parts of a space object as well as its launch vehicle and parts thereof."[40] In 2007, COPUOS produced a set of guidelines which uses the term space debris to mean "all man-made objects, including fragments and elements thereof." Despite the slight difference in meanings, the lack of consensus on definitions leaves an obscure legal starting point in which to build consensus for a space debris mitigation treaty. Second, although there have been some liability disputes on spacecraft that have crashed onto foreign soil, to date, *The Liability Convention* has not yet been invoked for any space debris damage caused by an incident in space. The lack of precedent setting cases could make questionable or difficult cases even harder to litigate as space operations become more complex. For example, liability becomes difficult to determine when international consortiums are able to launched multi-nationally owned satellites from international waters. Who should be held responsible under the Liability Convention if the satellite, after several orbital passes, damages another system? Should it be the international consortium because they launched at the wrong time, the satellite owners because they owned the offending asset or the nation of a tracking station because it failed to alert the now damaged satellite owners to the threat of collision? The liability questions of this multi-jurisdictional example are becoming less speculative as more space faring nations conduct multi-national operations.

Additionally, the lack of specific answers to fundamental questions, such as the boundary altitude where outer space starts, leaves only working definitions to defend any potential legal arguments. "UN Ambassador Arthur J. Goldberg, U.S. representative to the Outer Space Treaty Negotiations and advocate for ratification, testified before [U.S.]

Congress that a strict definition of outer space was unnecessary . . . at the time of the Outer Space Treaty negotiations, a definition of what constitutes outer space was purposefully not discussed."[41] The purpose behind the generality was much the same for the Outer Space Treaty as it was for many of the United Nations' space conventions. Refraining from specific definitions allowed member nations to continue negotiations while avoiding contentious issues, such as the sticking point of a moving space boundary line due to atmospheric differences at various latitudes or time of year. Two common "approaches for defining outer space has been spatial and functional . . . spatial . . . begins just below the lowest point at which an object can be maintained in orbit (about 52 miles) . . . [for] the functional approach . . . space begins just beyond the maximum height at which aerodynamic flight is possible."[42] No altitude is provided for the functional approach as aircraft continue to be enhanced for aerodynamic flight at higher altitudes.

The United Nations conducted various space debris studies throughout the 1970s and 1980s, but beyond basic recommendations no guidelines or treaties were produced. The studies did not gain much traction because, "some launching countries, while agreeing that space debris was an important issue, were concerned that specific space debris mitigation measures might be adopted which would later prove to be ineffective or unnecessarily costly."[43] Concerns about fair economic competition among space faring nations has been a contributing factor to the reluctance of member states to create additional treaties. United Nations' member states fear an economic disadvantages if required to bear additional space debris mitigation costs because of a treaty when non-member nations are exempt.

Recognizing that space debris is an unavoidable byproduct of space flight, several space faring nations independently implemented debris mitigation guidelines, including China, Russia, the European Space Agency and the United States. However, standards and compliance levels can vary from nation to nation because there is no internationally binding treaty. In January 2008, the United Nations' General Assembly followed suit and published the *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space*. The guidelines are not a binding agreement, but outline a set of practices aimed to reduce the threat of space debris, especially in low Earth orbit. The guidelines recommend mitigation practices and procedures for the "planning and operation of newly designed spacecraft and orbital stages."[44] The seven United Nations' guidelines are:

1. Limit debris released during normal operations.

2. Minimize the potential for break-ups during operational phases.

3. Limit the probability of accidental collision in orbit.

4. Avoid international destruction and other harmful activities.

5. Minimize potential for post-mission break-ups resulting from stored energy.

6. Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission.

7. Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission.[45]

The guidelines further define 'minimizing potential destruction' to include moving spacecraft out of low Earth orbit and geosynchronous Earth orbit after the mission is complete.

Thierry Sénéchal, Policy Manager with the International Chamber of Commerce, wrote a paper, *Space Debris Pollution: A Convention Proposal*, on the "Protocol for a Space Debris Risk and Liability Convention" which outlined the 2006 threat of space debris and the legal problems with the *United Nations Liability Convention*. According to Professor Lawrence Susskind and Professor William Moomaw, editors for "Papers on International Environmental Treaty-Making:"

> In Space Debris Pollution: A Convention Proposal, Thierry Sénéchal argues that it is time for an international space debris convention that would encompass the following objectives: 1) Implement an international and independent tracking and cataloguing system for space debris; 2) Adopt enforceable space debris mitigation and disposal guidelines; 3) Enforce a space preservation provision for protecting the most vulnerable outer space regions and; 4) Define a space debris compensation and dispute settlement mechanism.[46]

The difference between Mr. Sénéchal's proposals, other legal recommendations found within the literature review, and this thesis is that Mr. Sénéchal, and others, focuses on formal or legal connections and gaps between current binding policies and the *United Nations Liability Convention*, whereas this paper attempts to look at implementing a compliance program that would not require legally binding agreements. The compliance measures could be used as a stop-gap approach to take corrective action immediately rather than wait for the formal legally binding agreements which may never occur in the United Nations due to the need of consensus.

U.S. Law

*Space Law: Development and Scope*, published by the International Institute of Space Law in 1992, devoted a chapter to the history and development of U.S. space law. "The most important national law governing the development and scope of space law is the National Aeronautics and Space Act (NASA Act) of 1958."[47] The NASA Act invokes

the same spirit of cooperation, peaceful purposes and prevention of international conflict as the United Nations' Outer Space Treaty. Additional laws governing activity in space are mainly related to space commercialization, such as the Communication Satellite Act of 1962 and the Commercial Space Launch Act of 1984. The Commercial Space Launch Act "ensures compliance with international obligations of the United States and to protect the public health and safety, safety of property, and national security interests and foreign policy interests of the United States."[48] Although space debris is not specifically addressed, the spirit of the law would apply to mitigating space debris in order to limit damage and protect national security interests.

U.S. Policy

*The 2006 U.S. National Space Policy* provides guidance specifically on the mitigation of space debris. "The United States shall seek to minimize the creation of orbital debris by government and non-government operation in space in order to preserve the space environment for future generations."[49] The Space Policy calls for the United States to "take a leadership role in international fora to encourage foreign nations and international organizations to adopt policies and practices aimed at debris minimization."[50] *The U.S. National Space Policy* towards space debris is "to follow the U.S. Government Orbital Debris Mitigation Standard Practices, consistent with mission requirements and cost effectiveness."[51] Similar to the *United Nations Space Debris Mitigation Guidelines,* the four objectives of the *U.S. Government Orbital Debris Mitigation Standard Practices*[52] are:

1. Control of debris released during normal operations.

2. Minimizing debris generated by accidental explosions.

3. Selections of safe flight profile and operational configuration.

4. Postmission disposal of space structures.[53]

The deliberate wording of the space policy to include “consistent with mission requirements and cost effectiveness”[54] means that debris mitigation can be a secondary priority when national security is threatened or when economic viability of the mission is at risk.

The ISAB published a *Report on U.S. Space Policy* on 25 April 2007. The ISAB noted that the 2006 policy does not differ significantly from the 1996 National Space Policy. The ISAB reported that the current U.S. space policy focuses primarily on access to space and threats from direct fire. The report states that “survivability of our space assets in a deliberately hostile environment must be a requirement along with improved capabilities.”[55] The ISAB focuses on protecting assets in “deliberately hostile environments,” and from threats by direct attack; however, the recommendations do not sufficiently address the threat from space debris caused by operational missions or by a non-directly hostile but deliberate debris creation event, such as the Chinese anti-satellite weapon test. Mitigation of space debris is mentioned as an idea to be promoted, however there are no specific recommendations listed to implement compliance programs for the *United Nations Space Debris Mitigation Guidelines*.

As the dependence on advanced technology grows in the United States, so does the interest to protect U.S. national security assets in space. The trend to incorporate products of space operations into domain will accelerate because of its ability to enhance economic growth and prosperity. According to Mr. Goldman, an adjunct professor of space law at the University of Houston, “prowess in space will become increasingly the

measure of power on Earth . . . prowess will also be an ingredient in national power."[56] Mr. Goldman concluded in his 1992 book, *Space Policy: An Introduction*, that the U.S. space program lacks "a consistent high-level and coherent policy . . . with increasingly diverse but interactive operations in space, it has become imperative that a policy and organization be created that coordinate the potentially conflicting needs of the space sectors."[57]

The issue of effective domestic space policy is exacerbated when projected on an international level. For example, unless U.S. space systems are protected and coordinated through legal means or policy, responsibilities for liability and space control will remain fuzzy gray lines and will result in duplicated efforts in some areas while leaving gaps in other parts of the overall space control system. Replicate the disjointed efforts across several countries and then attempt to merge the various disjointed efforts for international cooperation and a system rife with overlap and gaping holes emerges. The current space debris mitigation efforts operate in this disjointed system because there is no international enforceable standard. Although Mr. Goldman's book on space policy does not address space debris specifically, it highlights the imbalance between the necessity of U.S. space operations and the lack of significant domestic policies and legal coverage. The lack of coordination and policy on the international level further places U.S. national security interests at risk.

## How Effective are the Formal and Informal Space Debris Mitigation Measures?

A review of literature on the effectiveness of formal and informal space debris mitigation can be separated into two broad categories: mitigation techniques, and space

surveillance and tracking. Space surveillance and tracking is actually a subcategory of mitigation techniques, but because of the industry's reliance on space tracking for collision avoidance it has been discussed separately in this paper.

Mitigation Techniques

The American Institute for Aeronautics and Astronautics initiated a study in May 1989 (updated in 1992), to "provide guidance to the AIAA [American Institute for Aeronautics and Astronautics] Standards Program on the mitigation techniques most promising for technical standardization and to recommend national and international regulatory options."[58] According to the study,

> There are four general sources or classifications of orbital debris: discarded rocket bodies, inactive payloads, debris from the operation of spacecraft, and fragments caused by collisions or explosions . . . [and] "mitigation techniques" refer to a broad spectrum of debris minimization or reduction measures that may be implemented, either through hardware design or spacecraft operation. They include techniques for prevention of debris generation, spacecraft disposal or active removal, and protection of spacecraft through shielding or collision avoidance. Shielding and collision avoidance techniques are adaptive as well as mitigating; that is, they are used to improve spacecraft survivability in a worsening debris environment while also preventing the creation of more debris by protecting the spacecraft from collision.[59]

The study surveyed debris mitigation techniques that were already in use, and techniques considered, by industry, civil government agencies, and organizations involved in space operations. The American Institute for Aeronautics and Astronautics found a variety of voluntary techniques had been adopted within the space industry in varying degrees, including mitigation practices by the private sector that indicated "some level of corporate self interest,"[60] rather than any response to government regulation. The results of the survey found the four "most promising" techniques for standardization and possible future regulation were venting residual fuel and pressurants from discarded

rocket bodies; boosting satellites from geosynchronous Earth orbit into disposal orbits; de-orbiting spent hardware; and reducing operational debris.[61] These four techniques closely mirror current *U.S. Government Orbital Debris Mitigation Standard Practices* (listed above).

The thrust of the American Institute for Aeronautics and Astronautics study found industry initiatives laudable but not sufficient. Generally, the report concluded that immediate actions need to be taken to reduce the threat of debris while finding an internationally balanced long-term solution. The preliminary conclusion of the study found

> Since there are already some orbital debris mitigation techniques in practice, greater attention should be given to implementing the most technically mature and least costly of these on a broad basis in the next few years. To the extent that any of these measures will be implemented unilaterally by the U.S., or not fully adopted by all launching states, special care must be taken to ensure that the competitive position of the U.S. will not be unduly adversely affected. . . .Given the continuing worsening of the orbital debris problem, and the inevitable delays that would be experienced in confronting it only through voluntary action, however, careful consideration also should be given to accelerating the implementation of debris minimization measures through the judicious use of various national policy instruments, including incentives and regulations.[62]

The American Institute for Aeronautics and Astronautics summarized its findings as a good start for efforts by the United States to focus attention on the problems of space debris in a more coordinated manner; however, there was still a lot of room for improvement.[63]

## Space Surveillance and Tracking

The emphasis on tracking space debris has increased over time because of the increased congestion in popular orbits and a growing concern over short and long term manned space missions. According to a statement by Nicholas Johnson, NASA Chief

Scientist for Orbital Debris, to the House of Representatives on 30 April 2009, "during 2008, NASA twice maneuvered robotic spacecraft of the Earth Observation System in low Earth orbit and once maneuvered a Tracking and Data Relay Satellite in geosynchronous orbit to avoid potential collisions. Twice since last August, the International Space Station has conducted collision avoidance maneuvers."[64] Nearly seven months later in November 2009, UniverseToday.com reported

> Hugh Lewis of the University of Southampton [speaking at the European Air and Space Conference in Manchester, United Kingdom], estimated the number of close encounters between objects in orbit will raise 50% in the next decade, and quadruple by 2059. . . Lewis has determined that compared with the 13,000 close approaches per week now, he projects there will be 20,000 a week in 2019 and upwards of 50,000 a week in 2059 . . . says Lewis, "You're going to need more tracking to remove uncertainty about close approaches and undertake more maneuvers."[65]

The growing density of space debris to nearby operational assets places a greater value on the ability of the United States to track orbital debris threats.

The U.S. Space Surveillance Network uses 30 sensors[66] worldwide to monitor over 19,000 space objects, mostly debris, in areas where manned spacecraft orbits. Even so, the space station and space shuttle are damaged regularly by micro-particles. According to Wired Science, a search of Johnson's Space Center Hypervelocity Impact Database "revealed that in the 54 missions from STS-50 [June 1992] through STS-114 [July 2005], space junk and meteoroids hit [the space] shuttle windows 1,634 times necessitating 92 window replacements."[67]

One of the complex issues with space surveillance and tracking is the political and security issues tied to the program.

> The U.S. Space Surveillance Network . . . has moderated access to its data since 2004 out of concern for national security. Russia maintains a Space Surveillance System using its early-warning radars and monitors some 5,000

> objects (mostly in LEO), but does not widely disseminate data. The European Union, Canada, China, France, Germany, and Japan are all developing independent space surveillance capabilities.[68]

According to Lieutenant General Larry D. James, Commander of the Joint Functional Component Command for Space for U.S. Strategic Command, as of 2009, the U.S. tracking system generally provides an accurate four-day forecast for space debris, which is ample time for mobile systems such as the space shuttle. However detection could be less than half a day for smaller unpredictable debris which could pose a significant threat to less maneuverable assets such as the International Space Station which needs about 30 hours notice to move.[69] Although the current U.S. tracking system is primarily ground based and can be affected by weather conditions, the SBSS System is expected to provide better detection and tracking capabilities. The SBSS System, scheduled to initially launch in 2010 is, at the time of this report, on indefinite hold due to concerns with the launch platform, "is intended to detect and track space objects, such as satellites, anti-satellite (ASAT) weapons, and orbital debris."[70] However, the fundamental problem of moderated and denied access to data will not be resolved with the initiation of the SBSS system. In fact, access to data may be further restricted if the SBSS system has improved optical sensor capabilities which can detect significantly smaller pieces of debris but creates a security concern over disseminating data that can reveal its technological advantage for tracking anti-satellite weapons.

## Summary

The threat of space debris to current operations is a growing concern in the space industry. U.S. national security interests are not sufficiently protected from the threat of space debris through the current formal or informal debris mitigation frameworks. It is

important to mitigate the growth and, if possible, begin to diminish current amounts of orbital debris in order to keep popular orbits at acceptable risk levels. An underlying problem is the inability to enforce mitigation practices that are only partially implemented or completely ignored by private industries or space faring nations. Enforcing standards on an international level is required to truly mitigate space debris because space is an environment that is used by the international community. The findings and recommendations of this paper are meant to address the growing threat of space debris and help protect the vital service performed by functioning satellites. The following chapters will provide the methodology, associated analysis, conclusions and recommendations that answer the primary question: what compliance measures could be taken to strengthen mitigation guidelines to better protect U.S. space assets from space debris?

The next chapter describes the research methodology used to answer the primary research question: what compliance measures could be taken to strengthen mitigation guidelines and better protect space assets from space debris? A literature review was conducted and two case studies were analyzed. Chapter 4 summarizes the analysis to determine if a similar compliance program is feasible for the *United Nations Space Debris Mitigation Guidelines*. Chapter 5 provides a conclusion based on the findings of chapter 4. Compliance methods should be established to serve as a stop-gap solution that improves conformity with the international standards. In addition to the conclusions, a set of recommendations are offered to address the problem of international compliance with the *United Nations Space Debris Mitigation Guidelines* in order to better protect U.S. national security interests.

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# CHAPTER 3

# RESEARCH METHODOLOGY

Every mission launched into space creates space debris. The United States has adopted policies to mitigate space debris; however only voluntary guidelines govern the debris mitigation activities of the international space faring community. Since there is no “check and balance” approach or binding authority to ensure that other space faring states or private industries follow current United Nations’ voluntary guidelines, space debris continues to pose a significant threat to U.S. national security interests. Recent space events that have created substantial amounts of space junk, such as the Chinese anti-satellite test in 2007, underscored the need to address the rising threat of space debris to operational space-based systems. The analysis for this thesis will attempt to determine what compliance measures could be taken to strengthen mitigation guidelines in order to better protect space assets from space debris.

A literature review was conducted to answer the three secondary questions: (1) what is the current space debris environment, (2) what is the connection between space debris and U.S. national interests, and (3) what formal and informal legal structures govern the mitigation of space debris? Three recent events have significantly altered the debate on debris mitigation compliance. The Chinese decision to test an anti-satellite weapon on the Feng Yun-1C, the emergency destruction of the United States NROL-21 satellite, and the unprecedented accidental collision between Cosmos 2251 and Iridium 33, denoted three landmark events that have shaped current attitudes towards debris mitigation activities.

Over the past decade, national infrastructures and economic growth have increasingly become interdependent on space products and capabilities. Because of the interdependence, the threat of space debris to military, civil, and commercial satellite systems can be considered a threat to national security interests. Because space law and international agreements are loosely written in order to maximize the utilization of space in the most unrestrictive way possible, the weakness in the frameworks governing the propagation of space debris means that legal accountability is nearly nonexistent. Decreasing and mitigating the amount of space debris is left to the internal policies and national interests of individual states who by nature have conflicting and asymmetric priorities causing gaps in international standards.

## Methodology

A research methodology was used to collect and analyze information to answer the primary research question: what compliance measures could be used to strengthen mitigation guidelines and better protect space assets from space debris. The methodology includes a literature review and analysis of two case studies. The findings of the analysis were used to formulate conclusions and provide a set of recommendations to effectively implement a space debris compliance program.

Qualitative information was gathered from the literature review to determine what options are available to better protect U.S. national security assets in space. Qualitative information gathered from the case studies was used to compare and contrast compliance methods of two international organizations with international standards. The case studies were used to determine if compliance with space debris mitigation guidelines could be implemented and if the compliance methods could be effective.

The two case studies provide a description of the compliance methods for the United Nations Social, Humanitarian and Cultural Affairs Committee and the Financial Action Task Force, international groups that focuses on human rights issues and financial crimes respectively. The first cases study was selected because it was a United Nations Committee that was similar in structure to COPUOS. The second case study was selected because of the compliance measures implemented for non-binding recommendations, a set of international standards similar in legal status to the *United Nations Space Debris Mitigation Guidelines*. The case studies provide a benchmark to assess the feasibility and effectiveness of implementing a compliance program for space debris mitigation.

## Strengths and Weaknesses

There are inherent strengths and weaknesses when using a methodology based on case studies. The two case studies used to determine if a compliance system was feasible for the *United Nations Space Debris Mitigation Guidelines* were selected because of the similarities to the international structure of COPUOS and the relevance of the compliance system for recommended international standards. The case study approach to analysis for this paper was chosen because of the complex nature and scope of information available on international compliance programs.

A fundamental strength of using case studies is the ability to use data from existing programs to predict the feasibility of similar programs. The case studies used for analysis of this paper allowed for detailed comparisons of information as a benchmark for establishing a compliance program for space debris mitigation. The case studies allow for differences in international and national interests, priorities, and legislation to be taken into account since a quantitative scientific study with controlled experiments was not

feasible within the scope and timeframe of analysis for this paper. Finally, the case study approach permits an overall qualitative approach for using available information.

The weakness of a case study approach to analysis is the inability to conduct a pure scientific study using quantitative data. The case studies have an amount of subjectivity and interpretation of events inherent to the process. The lack of a substantial sample pool also limits the reliability of the findings. In addition, the case study approach to gather qualitative information on international organizations does not limit the variables that may or may not influence the results, such as national cultures, member participation, international attitudes and climate toward the issues, and other unrecognized influences.

## Summary

This paper focused on the types and effectiveness of compliance measures of international organizations to enforce international standards, in order to answer the primary question: what compliance measures could be taken to strengthen space debris mitigation guidelines and protect U.S. space assets from space debris. In order to complete the study a research methodology was used to conduct a literature review and analyze two case studies. The next chapter summarizes the findings of the research. Analysis conducted on the two case studies was used to determine if a similar compliance program is feasible for the *United Nations Space Debris Mitigation Guidelines*. Chapter 5 provides a conclusion based on the findings of chapter 4 and a set of recommendations to address the problem of international compliance with the *United Nations Space Debris Mitigation Guidelines* in order to better protect U.S. national security interests.

# CHAPTER 4

# ANALYSIS

With thousands of tennis ball, or larger, sized pieces of space debris acting like sticks of dynamite and millions of space debris particles acting like orbiting bullets, the U.S. Government, like all space faring nations, enters a high risk environment whenever a satellite is launched into orbit. Because of the United States' dependence on space based assets, the threat of space debris should be regarded as any other threat to national security interests. Although the current U.S. policy towards mitigating space debris will limit the amount of orbital debris created by the U.S. space industry, other space faring organizations may not always adhere to similar practices. Since there is no 'check and balance' approach or binding authority to ensure that other space faring nations or private industries follow the current *United Nations Space Debris Mitigation Guidelines*, there is a threat to U.S. national security.

The literature review indicated that the United States has an increasing national security interest in protecting space assets because of the growing reliance on military, as well as, commercial satellites. The literature review also indicated that the international treaty, conventions, and agreements governing space debris do not adequately protect U.S. assets from the threat of space debris. The gap in protection was apparent when China destroyed the Feng Yun-1C satellite creating thousands of lethal sized pieces of space debris in close proximity to several operational satellites, including seven owned by the United States, without breaking any international laws. The recent debris creating events of the Chinese anti-satellite test and the Cosmos 2251 and Iridium 33 collision

have significantly increased the amount of long-term debris now found in low Earth orbit, thereby exposing U.S. space assets to an increased risk of damage or destruction.

The recent debris creating events, in conjunction with increasing reliance on space based systems create an environment rife with potential danger to U.S. national security interests. Despite the threat, the U.S. national space industry remains concerned about any regulation that will restrict access to space; therefore, stricter regulations to mitigate space debris remains tabled in favor of maintaining maximum flexibility for accessing space. Lastly, the literature review indicated that current, long-term reactive solutions, such as space tracking systems to avoid space debris damage from future anti-satellite activity or accidental collisions, remains disjointed. This chapter will provide details on the analysis conducted to answer the three secondary questions: (1) what is the current space debris environment, (2) what is the connection between space debris and U.S. national interests, and (3) what formal and informal legal structures govern the mitigation of space debris? Five screening criteria, (suitability, feasibility, acceptability, distinguishability, and completeness), were used to analyze the two case studies to determine if a compliance program could be implemented for space debris mitigation.

## What is the Current Space Debris Environment?

Chapter 1 discussed the physical space debris environment, such as the 20,000 pieces of tracked space items and the hundreds of thousands of smaller space debris particles. With only an approximate 920 of the 20,000 objects constituting operational systems, the issue of space debris poses a significant threat to daily space based operations. Chapter 2 outlined three major events that shaped current attitudes towards space debris. The three events were the intentional destruction of the Feng Yun-1C

satellite by China, the intentional destruction of the NROL 21 satellite by the United States, and the accidental collision between the Russian Cosmos 2251 and American Iridium 33 satellites. The analysis of this section will focus on what, if any, international measures were put in place after each of the three debris creating events In order to prevent future occurrences from causing large amounts of long-lasting space debris.

### Reaction to the Chinese Destruction of Feng Yun-1C

The on-going 20-plus year debate within COPUOS for stricter space debris controls may have continued with unproductive results if it were not for the general disparagement over the lack of public notice regarding potential debris danger leading up to the Chinese anti-satellite test and the resulting long-lasting debris cloud. After the anti-satellite test, the outcome of the renewed talks within the United Nations' COPUOS was to publish a set of unbinding mitigation guidelines. However, the lack of strength behind the *United Nations Space Debris Mitigation Guidelines* and the inability of the international community to enforce compliance meant that no legal obstruction was established to preclude similar actions causing large, long-lasting debris fields from occurring in the future.

In fact China, as a full member of the IADC, had adopted the IADC space debris mitigation guidelines in 2002, prior to the Chinese anti-satellite test, but failed to comply with the intent of the standards. The IADC guidelines closely match the *U.S. Government Orbital Debris Mitigation Standard Practices.* The IADC and U.S. space debris guidelines served as precursors to the United Nations' debris mitigation guidelines. The IADC guidelines are (1) limit debris released during normal operations, (2) minimize

potential for on-orbit break-up, (3) post mission disposal, and (4) prevention of on-orbit collision. Agreeing to comply with the voluntary IADC guidelines did not prevent China from breaking all four policies during the anti-satellite test and creating the long-lasting debris cloud. Therefore, had the United Nations version of space debris mitigation guidelines been in place, China would have broken more guiding principles, such as the guideline to avoid international destruction and other harmful activities, but still would not have violated any international law or policy.

Since the United Nations' guidelines are voluntary, space faring organizations can create debris unintentionally because of lax standards or intentionally for hostile and non-hostile (emergency or testing) reasons, without concern of legal recourse unless damage to another space system can be directly attributed for liability. The lack of an international-level space debris mitigation compliance program continues to leave U.S. space assets vulnerable to debris damage.

### Reaction to the United States Destruction of NROL-21

The public outcry over the debris cloud created by the Chinese anti-satellite test gave the United States cause to increase its efforts when faced with the need to destroy one of its own unresponsive satellites. By 2008, when the NROL-21 was due to be destroyed, COPUOS had adopted the *United Nations Space Debris Mitigation Guidelines*, which expanded on the IADC's version. The United States, being members of both the COPUOS and IADC, took several measures to meet the *United Nations Space Debris Mitigation Guidelines* as well as national-level policies for debris mitigation. For example, the United States waited until the unresponsive NROL-21 was near the Earth's

atmosphere before destroying the satellite to ensure the debris would degrade out of orbit quickly.[1] The United States also publicly announced the need to destroy the satellite which provided a warning to other space faring nations about the potential danger from the pending debris cloud.[2] Although reactions from the international community were mixed because the political motives were questioned, the practices and techniques used to destroy the NROL-21 satellite have been upheld as a positive example for space debris mitigation for controlled satellite destructions.

## Reaction to the Collision between Cosmos 2251 and Iridium 33

The collision between Iridium 33 and Cosmos 2251 indicated that the space around the Earth was becoming cluttered. The accident added a sense of urgency to the international community’s effort to find solutions to prevent, and if possible, reduce the current amount of debris. In addition, the accidental collision between the Russian Cosmos and American Iridium satellites brought the threat of space debris to the consciousness of the general population which added some public interest for finding solutions to the growing threat. However, the general population’s awareness, though growing, will most likely not carry enough weight to affect the necessary change in space debris mitigation until damage from space debris begins to disrupt routine public use, such as flight delays due to global-positioning system outages.

The Iridium 33 and Cosmos 2251 accident caused the space faring industry to accept the fact that the tipping point for usability of certain popular orbits may be in jeopardy. Renewed discussion on space debris mitigation efforts occurred; however, unlike the Chinese anti-satellite test where the discussions focused on the need for

stronger legislation and enforcement, the discussions about the accidental collision focused on the need for better tracking and cooperation. Chapter 2 discussed the seriousness of the Cosmos and Iridium accident, such as the large debris clouds, the gaps in the debris tracking system that allowed the collision to occur, and the issue of legal liability. The international discussions on the need for better tracking and cooperation are only reactive measures to address a symptom of the core problem, the initial creation of space debris. Despite the seriousness of the collision no international agreements for stronger mitigation or compliance controls were established to address the core problem. The accident was, for all intensive purposes, considered an unfortunate event but not destructive enough to change current attitudes towards implementing stronger regulations or a compliance system within COPUOS.

## What are the Connections between Space Debris and U.S. National Interests?

Chapters 2 discussed the connection between space debris and U.S. national interests in terms of defining national security, the U.S. reliance on space based operations, and the ways the United States tries to protect space assets from space debris. The literature review indicated that national security interests include military, civil and commercial space based systems. The U.S. is heavily reliant on satellite systems for protection and defense, as well as economic growth. The public's reliance on space systems is growing because space based products are often incorporated seamlessly into everyday life. The literature review also indicated that although space based assets are protected through space tracking and shielding, the preventative measures have weaknesses which lead to gaps in protection, such as non-complete coverage for tracking

or insufficient shielding for space debris between one and ten centimeters long. The analysis for this section will focus on what effect each of the three debris causing events discussed in chapter 2 had on U.S. attitudes towards national security assets in space.

The Chinese anti-satellite test demonstrated that even if a nation has debris mitigation policies, as China did at the time of the anti-satellite test, a country may not follow domestic or international standards. China's destruction of the Feng Yun-1C weather satellite caused the U.S. Secretary of State's ISAB to produce a set of recommendations in 2007 that urged the United States to take a strong stance on space security. The outcry from the international community regarding the amount of space debris created from the Chinese anti-satellite test had an impact on the approach that the United Stated took when required to conduct a similar operation against the NROL-21. To avoid similar backlash over the creation of space debris, the United States took several steps to mitigate fragmentation and maximize degradation of debris created from the destruction of the National Reconnaissance Office's satellite approximately one year later.[3]

The results of the Cosmos and Iridium satellite collision caused the Joint Space Operations Center to bolster its satellite tracking capabilities in order to monitor all operational satellites. "At the time [of the Cosmos and Iridium collision], the Joint Space Operations Center (JSPOC) . . . was monitoring about 140 spacecraft for possible collisions. That number has been on the rise since, and officials plan to routinely conduct potential-collision analyses on 800 spacecraft by this fall [2009]."[4] Although the United States continues to enhance debris tracking capabilities and follow established debris

mitigation policies and guidelines, space based systems remain at risk of damage by space debris since other space faring organizations may not adhere to similar practices.

The connection between national security and space debris is significant. Private and government entities agree that mitigating the exponential growth of future debris is important. Although U.S. policy to proactively mitigate space debris is incorporated by government agencies and private industries, the viability and operational cost of launching the satellite still takes a priority over the cost of implementing every space debris mitigation measures. Therefore, even in the United States, debris mitigation may not always be fully implemented within the space industry.

Additionally, there are concerns about unfair competitive disadvantage for organizations within the space industry that adhere to debris mitigation guidelines when other nations and organizations do not comply to save costs. "Some space-faring powers still have not completely embraced the idea of mitigation practices, concerned that added costs might hamper their ability to develop competitive space industries."[5] Beyond space faring nations, the concerns over economic competitiveness and implications of shady debris mitigation practices is increased when theorizing about private space companies' activities.

> Mitigating space debris creation is very expensive, when private activities are concerned . . . given the competition, some entrepreneurs will try to avoid those [space debris mitigation] measures by conducting their activities under a more favorable law. Doing so, they will get a great competitive advantage. It is already the case for sea activity; why should it be any different for outer space?[6]

By implementing an internationally binding agreement or compliance program, the entire space industry would be subject to the same standards and concerns about economic disadvantages would diminish.

The growing amount of space junk has led to an increase in news reports, such as space shuttle maneuvers due to possible collisions with space debris and the slightly less spectacular debris creating event of the Russian's Briz-M rocket stage that exploded in February 2007 adding over 1,000 pieces of debris to low Earth orbit (as depicted in chapter 1, figure 1). Despite the recent attention that space debris has received from news reports, the threat has not garnered any renewed efforts from the United States or the international community to make the space debris environment less risky through formal agreements. The lack of an international level compliance program leaves U.S. national security assets vulnerable. Whether the space asset is damaged or destroyed by orbital debris from a normal operational launch, an overt hostile act, or from a foreign non-hostile act, the event has the same end result for the United States, a disruption in service and loss of millions of dollars in production and operational costs.

## Options Available to Protect U.S. National Security Interests in Space

Since doing nothing is not a viable solution, there are three options that the United States can take when protecting national security interests from the threat of space debris. The first option is to lobby for stronger international laws and implement stronger U.S. laws or policies; the second option is to take a harder stance to protect national security assets by denying others; and the third option is to implement an enforceable compliance program at the international level. Although all three options could be pursued together, option three is the recommendation of this thesis based on the feasibility to implement a program on an international level.

Option One: Lobby for Stronger International Laws and Implement Stronger U.S. Laws

The literature review revealed the need for stronger international laws and policies to protect the assets of space faring countries from space debris. The current international conventions only cover liability reparation for damage caused by another space faring country. To date, the *Liabilities Convention* has not been used for space based damage and lacks sufficient precedent setting cases to rely on for decisions based on anything beyond the most straight forward liability cases. While mitigation of space debris continues to be a voluntary and self-imposed concept, future litigation cases will be rife with legal loopholes and questions.

If a U.S. asset is damaged, the United States can apply for liability reparation; however, the ability to determine who is ultimately responsible can often be difficult because of the number of contributors involved in making space operations possible. For example, when the defunct Russian Cosmos satellite collided with the operational American Iridium satellite, there was no reparation paid. An article written in Worldwide Satellite Launches, published by Phillip Clark/Molniya Space Consultancy on 18 February 2009 found that:

> According to Russian statements, Cosmos 2251 had not been operating since the mid-1990s and it was known not to carry any in-orbit maneuvering system. Therefore, Iridium 33 was apparently capable of performing a small maneuver to prevent the collision with Cosmos 2251. . . . While the United States Space Surveillance Network tracks all objects in orbit and monitors possible collision, it is not responsible for warning commercial satellite users of potential threats; that responsibility lies with the satellite operations. One could therefore conclude that it was the responsibility of orbital analysis staff with Iridium Satellites LLC to monitor Iridium satellites for possible close approaches to other objects and then maneuver the Iridium satellite slightly to ensure that the projected close approach distance is significantly increased.[7]

Although, as noted above, the Joint Space Operations Center is expanding to track all operational satellites, the findings still point to future liability problems with the U.S. space debris tracking system. Will the Joint Space Operations Center be responsible if it fails to identify a close approach? Who is responsible if the warning is not received in enough time to move the satellite out of harm's way? With the growing reliance on commercial satellite systems, weaknesses in the tracking system leave a gap when trying to maintain the safety of U.S. national security interests.

The literature review indicated that legal experts who have studied international space laws and policies agree that the current legal structure is weak. The legal weaknesses pose several concerns for litigating disputes as space operations and the space environment becomes more complicated and crowded. A 2006 study on the "Protocol for a Space Debris Risk and Liability Convention," conducted by Thierry Sénéchal, Policy Manager with the International Chamber of Commerce, looked at loopholes within the *United Nations Liability Convention* and the creation of space debris. The final recommendation from the study was to implement a five-year plan to establish a global convention for space debris mitigation that would enhance "the principles for dispute resolution and liability damage."[8] The four objectives of the convention would be to implement an independent tracking and cataloguing system of space debris; adoption of enforceable space debris mitigation and disposal standards; space preservation provision to protect scientific and economical important orbits in low Earth and geostationary Earth orbits; and a clear mechanism for "liability, compensation and dispute system design under which a final and enforceable decision can be obtained."[9] The adoption of the United Nations' guidelines for space debris mitigation in

2007 partially satisfied the second recommendation of Mr. Sénéchal to adopt enforceable space debris mitigation and disposal guidelines. However, the pragmatic legally binding approach prescribed by Mr. Sénéchal, and other legal experts, is not realistically attainable in the current climate of the United Nations unless a space debris event of immense magnitude occurs, such as one that causes loss of life or severely impacts a nation's capability or economy.

As the literature review revealed, the United States supports mitigation measures, yet it does not actively seek tighter laws that could make space operations less profitable or hinder access to space. Therefore, the call for stronger international laws by legal experts such as Thierry Sénéchal and those from the European space community have been deadlocked in the United Nations partially by the lack of U.S. support and partially by disagreements among member nations over definition discrepancies. Because the United States is generally opposed to stronger international laws, the option of advocating for stronger legislation has been politically tabled. However, a review of space debris mitigation and litigation issues should be considered due to the ever increasing threat and complications that space debris poses to national security assets and the accompanying freedom of access to operational orbits.

### Option Two: Protect Assets Against Threats in Space Through Force

Unlike Option One, advocate for stronger laws, which the United States has generally rejected; Option Two has been considered by the ISAB. A study was conducted by the ISAB after the Chinese anti-satellite test to recommend new national security strategies towards space. The 2007 ISAB *Report on U.S. Space Policy* emphasizes a

harder stance against enemies in order to protect U.S. freedom of access to space and American space based interests from direct fire threats.[10]

Although the recommendations by the ISAB presents a stronger strategic stance on protecting U.S. assets and national security interests, the report does not provide additional recommendations beyond the current space policy to limit or protect assets from the threat of space debris. There is an inherent danger to taking a stronger stance in the space environment in order to protect U.S. assets without addressing how the protection also mitigates the creation of additional orbital debris. A stronger stance through force against ground-based systems or by non-kinetic space-based actions may be a viable solution; however the ability to maintain freedom of access by kinetic actions in space has to be balanced with maintaining an environment free of debris so that the orbits stay operationally viable. For example, if a country were to destroy a U.S. space asset, the result would create a new debris field. If the United States were to retaliate, then a second debris field would occur. The more each nation retaliates, the more the debris fields would grow.

The Liability Convention would enforce the compensation for any assets damaged in hostile or retaliatory strikes, but if direct hostile acts were taken by either nation, liability reparation would be the least of the problems because the secondary affects would be far more problematic. The disputed regions of space would, at best, be more cluttered until a bulk of the debris degraded and reentered the Earth's atmosphere. At worse, the disputed regions would become completely unusable for hundreds or thousands of years. Similar to a nuclear stand-off, there is little ultimate gain for the offending or offended space faring nation to attack its enemies in space. The outcome

only serves to create an environment where the orbit is no longer usable for the offending or defending country. Therefore, a stronger stance on kinetic force against direct threats in space, only serves as a deterrent for operations that occur in the lowest of Earth’s orbits. Therefore, Option Two is a partial solution for direct attack; however, a stronger stance through force does not sufficiently protect all U.S. national security assets from space debris.

### Option Three: Create a Compliance Program that an International Organization can Implement

An international peer-monitoring type group is the best short to medium term solution for implementing a compliance program to mitigate future space debris in accordance with United Nations’ guidelines. The peer-pressure group would increase compliance with the international standards despite the lack of a binding debris mitigation agreement while equalizing the concerns over economic hardships placed on nations who comply. Although there are groups studying the effects of space debris and making mitigation recommendations, such as the European Space Agency Space Debris Working Group and the IADC, no international organization has the enforcement power to hold countries, or the space industry, accountable for compliance with international guidelines. A peer-monitoring group is the type of organization that can bridge the gap between conflicting nation-state interests while improving compliance standards with United Nations’ guidelines. The benefit of a peer-monitoring group that applies peer-pressure is that while compliance standards would increase, it would do so without the formality of creating an international convention which has been unsuccessfully attempted throughout the previous two decades. The compliance program would not be

recognized as a formal international convention; however, it would act in the spirit of an international agreement. Analysis, in the following section, was conducted on two international groups with peer-review programs to determine if a similar compliance program is feasible for the *United Nations Space Debris Mitigation Guidelines*.

## What Formal and Informal Legal Structures Govern the Mitigation of Space Debris?

The literature review revealed formal and informal structures that govern the mitigation of space debris, such as COPUOS and private industry's debris mitigation practices. However, the literature review also revealed that the current structures did not have the ability to effectively implement the policies and guidelines that underpin the mitigation of space debris. The following analysis compares two international groups to explore (1) the established compliance program and (2) the effectiveness of the compliance policies on the corresponding industry. The United Nations Social, Humanitarian and Cultural Affairs Committee, known as the "Third Committee" and the Financial Action Task Force (FATF) are two examples of international bodies that create a form of regulatory policy or recommendations similar in legal status to COPUOS guidelines. The United Nations Third Committee was selected as a case study because the Committee demonstrated the ability for United Nations' organizations to have a peer-review process; therefore a similar compliance program should be feasible for the United Nations' COPUOS. The FATF was selected as a case study because the peer-review process is more robust and provides additional levels of compliance monitoring. The two international bodies were used to develop a model for incorporating a compliance program for the *United Nations Space Debris Mitigation Guidelines*.

## Compliance Measures and Effectiveness: The United Nations Social, Humanitarian and Cultural Affairs Committee

The United Nations Third Committee focuses on "items relating to a range of social, humanitarian affairs and human rights issues."[11] Because of differences in political views stemming back to the Cold War, the Third Committee passed two separate human rights agreements in 1966, the *International Covenant on Economic, Social and Cultural Rights* and the *International Covenant on Civil and Political Rights*. The *International Covenant on Economic, Social and Cultural Rights* is monitored by the Committee on Economic, Social and Cultural Rights. The *International Covenant on Civil and Political Rights* is monitored by the Human Rights Committee. Self-reporting is the primary enforcement mechanism for both covenants; however, the *International Covenant on Civil and Political Rights* has some additional methods for compliance. The two covenants have separate implementation processes which have strengths and weaknesses that are common to enforcing standards in a formal international forum.

The strength of the covenants is that the self-reporting, a form of peer-monitoring, has had the desired effect of improving the compliance with international standards. According to Global Governance Watch:

> While the [Economic, Social and Cultural Rights] Committee's concluding observations, in particular suggestions and recommendations, may not carry legally binding status, they are indicative of the opinion of the only expert body entrusted with and capable of making such pronouncements. Consequently, according to the Office of the United Nations High Commissioner for Human Rights (UNOHCHR), for States parties to ignore or not act on such views would be to show bad faith in implementing their Covenant-based obligations. In a number of instances, changes in policy, practice and law have been registered at least partly in response to the Committee's concluding observations.[12]

The international disgrace brought upon a nation found in violation of international commitments is a significant contributing factor when assessing the effectiveness of peer-

pressure type compliance. Relatively few nations are insensitive to international opinion when it comes to respectability and views of conducting honorable neighborly activities. Because of a nation-state's desire to be considered trust-worthy in deed and practice, legislative changes to bolster or improve deficiencies announced publicly in international forums are often one of the first action items implemented.

Although, the peer-monitoring program for the Committee on Economic, Social and Cultural Rights has improved compliance there are two problems with enforcing the international standards. The first is the legal ability of the Committee to enforce compliance of the covenant tenants for domestic policies and the second is the ability to enforce member nations to comply with the self-reporting (administrative) process within the committee meetings. Because the covenant allows member nations to implement tenants to the "best of the country's ability," there is a fuzzy gray line when defining "best;" therefore, member nations have some latitudes in meeting the criteria.

> Since the covenant uses the financial state of a country to gauge its ability to provide the right, a democratic nation may argue that its capital should be better spent on democracy instead of the economic, social and cultural rights of its people. Consequently, a state that should provide more of these rights can simply point to the covenant and argue that its money can be used in other and more important ways.[13]

The second issue of administrative enforcement within the committee is the weakness of self-reporting.

> Member states are required to submit reports every six years on the progress they have taken to achieve the rights in the [covenant] . . . however, the committee has had a problem with states failing to even submit a report. Some of those submitted are written for the sole purpose of fulfilling the report obligation; they lack candor.[14]

The weakness with self-reporting is the lack of a 'check and balance' element to the process; however, the basic fact that the Committee has a reporting system at all is an

improvement to the current system in place for the voluntary guidelines of COPUOS. Since the Third Committee and COPUOS are both United Nations' committees, the fact that the Third Committee has a form of compliance measures indicate that a similar system could be implemented within COPUOS.

In 2006, when the Human Rights Committee was restructured, a new universal periodic review mechanism was implemented. The new process calls for all 192 United Nations' Member States signatory to the *International Covenant on Civil and Political Rights* to submit to a review process every four years.[15] The review process takes place within a working group consisting of 47 member states, the President of the Council, and three rapporteurs from among the Council members. The review process includes a three-hour interview with the country under review. During the interview members and observers can ask questions on "obligations stipulated in the Charter of the United Nations, the Universal Declaration of Human Rights, any human rights instruments to which the state under review is party, any "voluntary pledges and commitments" made by the state in question, and any applicable international humanitarian laws."[16]

Prior to the interview, the member nation submits a national report containing relevant information for the working group to evaluate the compliance level with the covenant. Additionally, other stakeholders are encouraged to provide relevant information regarding the status of the nation state under review. Following the interview, the working group issues a report summarizing the findings and provides a list of conclusions and recommendations for improvement.[17] The summary report is then forwarded to the plenary session of the Human Rights Council for adoption and public release.

Because the summary reports are publicly available on the United Nations' website, the international community can apply pressure to poor performers. The public disgrace of having an unfavorable review can often be the catalyst to persuade countries to make changes, or accept assistance from the international community to help make the changes, in order to meet standards and have a more favorable review released publicly. For example, in a 2001 article on British foreign policy efforts on human rights, Robin Cook, the British Foreign Secretary said the Commonwealth has, "great strength in exerting peer group pressure and none of its members relish being subject to criticism by the rest of the family of Commonwealth nations."[18]

Two additional enforcement methods available in the International Covenant on Civil and Political Rights include the ability for individuals and non-governmental organizations to submit complaints of human right violations.

> When received, the complaints are merely filed for record-keeping. However, if a large number of complaints against a certain state are received in a short period of time, the United Nations may decide to investigate. This method of enforcement has limited power, since the states violating human rights standards are not actually forced, but rather, only pressured into improving.[19]

The second enforcement method is similar to the complaint system for reporting on third party nation violations, except it allows individuals to complain about their own country's human rights violations at the international level.[20] The protocol allowing for individual complaints has significant limitations, "for instance, only complaints regarding human rights violations against an individual, not a group, can be filed . . . [and] all the possibilities to ameliorate the situation domestically must be exhausted."[21] The Committee's decision is not legally binding; therefore some states will rectify the situation while others will ignore the ruling.[22] However, the complaint system has been

generally proven successful in improving member nation's compliance with international standards. For example, "a group of New Zealanders [regarding violations against an individual] were able to invoke the International Covenant on Civil and Political Rights before the Human Rights Commission, and the Commission was able to prevail upon the Government to reverse a policy that violated the Covenant."[23]

Because the Human Rights Committee is a subset of the United Nations Third Committee, the self-reporting compliance program augmented with an interview could also be a feasible compliance program for space debris mitigation within COPUOS. The peer-monitoring compliance program would have the effect of increasing standards as countries make improvements in order to have reports listing positive findings posted on the web, likewise non-compliant countries with poor reports would be subject to international peer-pressure and scrutiny when the findings are publicly released. Although the self-reporting and self-reporting with interview process has flaws, the increase in compliance manifested through peer-monitoring has an overall benefit not currently realized in the COPUOS for space debris mitigation.

## Compliance Measures and Effectiveness: The Financial Action Task Force

The purpose of the Financial Action Task Force (FATF) is to develop and promote policies, "both at national and international levels, to combat money laundering and terrorist financing . . . [and] is therefore a "policy-making body" which works to generate the necessary political will to bring about national legislative and regulatory reforms in these areas."[24] The FATF established a set of international standards called the Forty Recommendations on Money Laundering and Nine Special Recommendations on

Terrorist Financing, known as the forty plus nine recommendations. The recommendations are not legally binding through the agreement of a treaty; therefore, the FATF has established a compliance system that is enforceable through peer-monitoring by member states and the international community. Because the FATF has limited its membership to a small but globally representative group of jurisdictions, seven other Financial Action Task Force Regional-Style Bodies (FSRB) have been established throughout the world so that non-FATF members could belong to a similar organization.

The FATF monitors the implementation of the recommendations by member nations through a mutual evaluation, or peer-review, process. The mutual evaluation process includes a self-report submitted by the country, a delegation comprised of approximately three other FATF members to conduct an on-site visit, and a review of the self-report and on-site findings during a plenary session. The FSRBs are patterned after the FATF and follow similar compliance review processes for their respective members.

The first step in the mutual evaluation process is for the member jurisdiction under review to submit a report describing the jurisdiction's compliance with each of the forty plus nine recommendations. In addition, the country submits documentation and self-reports on compliance with any additional national level anti-money laundering and counter-financing of terrorism (AML/CFT) legislation. Three different member jurisdictions volunteer to provide an AML/CFT specialist in one of the three on-site evaluation categories: law enforcement, regulatory and legal.[25] The international mix of specialists on the evaluation team provides a level of independent review and impartiality. The mutual evaluation assessment team verifies or clarifies the answers provided on the self-reported submission. The team also assesses the level of compliance

with the forty plus nine recommendations. The mutual evaluation team then submits a report to FATF and the country under review listing the findings and recommended areas for improvement.

Each of the forty plus nine recommendations is given a score of either: compliant, largely compliant, partially compliant, or non-compliant.[26] The self-submitted report by the country under review and the on-site mutual evaluation report are then discussed at a FATF or FSRB plenary session. During the plenary, the jurisdiction under review can advocate for upgrades to one or more of the grades assessed by the mutual evaluation team. In addition, during the review session the members and observers can ask the jurisdiction under review or the evaluation team questions for clarification or confirmation of certain facts contained in the reports. Members then vote to downgrade, upgrade or maintain disputed grades based on the interview process and the evaluation team's findings prior to the adoption of the report. Depending on the internal policy of the international organization, the final report may or may not be publicly released, however all member nations and international observers to the group will have access to the findings.

Member nations who do not meet international standards could be admonished from the corresponding governing body (either the FATF or FSRB). For serious violations, the jurisdiction could be placed under stronger scrutiny measures and subjected to enhanced monitoring programs that require extra reporting and more frequent mini-evaluations. The mutual evaluation system has proven to be very effective for increasing international standards. In 2000, the FATF developed the Non-Cooperative Countries and Territories Initiative. "The principal objective . . . was to reduce the

vulnerability of the financial system to money laundering by ensuring that all financial centres adopt and implement measures for the prevention, detection and punishment of money laundering according to internationally recognised standards."[27] A total of 23 countries were listed as non-cooperative jurisdictions in 2001. Based on international peer-pressure, and international intervention and assistance by 2006 all 23 non-cooperative countries had made enough improvement to be removed from the list.[28]

The FATF and COPUOS have a problem set with similar ramifications. For example, financial crimes undermine a nation's economic soundness by introducing illicit funds into the formal banking system. The country where financial crimes are occurring collect less tax revenue, faces increased corruption issues, and has instability within the financial system. Since money laundering is often an international crime, the weaknesses in another country's financial system can allow illicit funds to enter the banking system of a domestic jurisdiction. In other words, lax anti-money laundering policies in other jurisdictions can negatively impact the financial stability of the United States. Similar to space debris, the lax debris mitigation standards in other jurisdictions can negatively impact the national security interests of the United States. In addition, with the growth of the global economy, the countries that rely on the integrity of the U.S. financial system are also impacted when illicit proceeds undermine the financial stability of the legitimate transactions. Similarly, the countries that rely on the integrity of U.S. space based systems are impacted when space debris degrades satellite capabilities. The compliance systems of the FATF to address the threat of financial crime activity on an international level in order to protect domestic systems is a model for the international threat of space debris threat to domestic space based systems.

Compared to the pure self-reporting system of the Committee for Economic, Social and Cultural Rights, and the self-reporting with interview system of the Human Rights Committee; the mutual evaluation process established by the FATF and associated regional bodies has taken an extra step to include a ‘check and balance’ approach to compliance through the use of an on-site visit. Although the FATF is not a United Nations’ Committee, the organization operates as a formal international body; therefore, a similar mutual evaluation compliance program is feasible for space debris mitigation.

## Screening Criteria of a Space Debris Mitigation Compliance Program

Analysis of the compliance programs implemented by the United Nations Third Committee and the FATF indicated that a similar program could be established for the *United Nations Space Debris Mitigation Guidelines*. Screening criteria were used to “ensure solutions being considered [could] solve the problem.”[29] The five screening criteria used to determine if a peer-monitoring type international organization could increase compliance with *United Nations Space Debris Mitigation Guidelines* were suitability, feasibility, acceptability, distinguishability, and completeness.

### Suitability

Implementing a compliance program to strengthen the *United Nations Space Debris Mitigation Guidelines* is a suitable solution. Suitability is whether the solution “solves the problem and is legal and ethical.”[30] The suitability of implementing a compliance program for an international set of standards is demonstrated by the United Nations Third Committee and the FATF. Although the two international bodies have

different scales of compliance, the analysis indicates that a compliance program for the mitigation of space debris could meet legal and ethical standards.

Although a compliance program would improve space debris mitigation and lower the risk to U.S. national security interests in space, no solution would totally solve the problem of space debris. The space environment will never be risk free as long as particles and pieces of space junk orbit the Earth, not to mention the naturally occurring debris particles (meteors), and other operational space systems that could collide with U.S. space assets. Since total security of space assets is not achievable, the closest controllable measure to secure space assets would be adoption of a formal legally binding agreement. If a scale of zero to five were created with zero as no international standard and five as a formal internationally binding treaty (see figure 6), the recommendation of this thesis to implement a peer-monitoring type compliance program would fall below the standard of a treaty but above the non-binding guidelines currently in use by COPUOS.

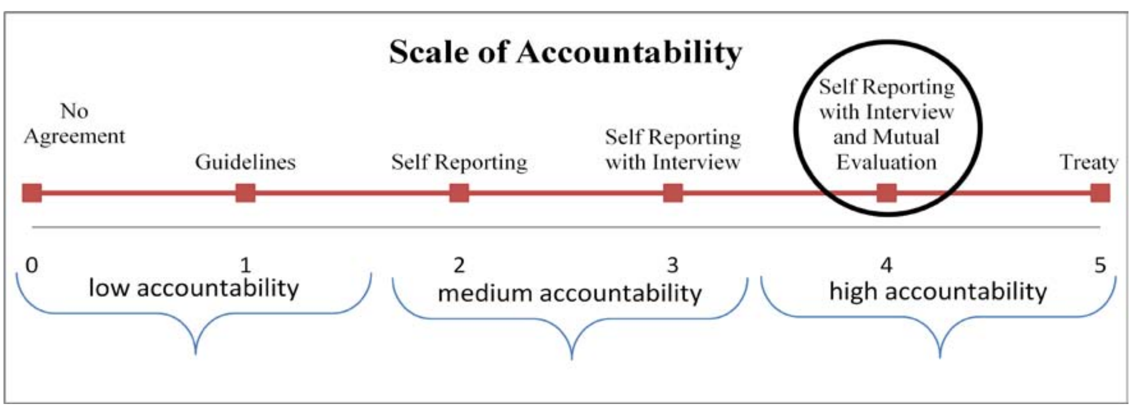


Figure 6. Scale of Accountability
*Source*: Created by author.

The scale of accountability represents a process of increased verification that would hold a nation state accountable for meeting the standards of debris mitigation. On the scale of accountability, the United Nations went from score of zero to a score of one with the creation of a standard set of guidelines, but without stronger accountability, a significant risk will remain that member states may not comply with the standards. By implementing a system where outside verification of self-reported information is required, a 'check and balance' approach to mitigate space debris creation would meet the intention of treaty without requiring nation states to achieve consensus over legal verbiage.

Unlike a treaty, which requires signatory nations to meet all of standards agreed upon, a compliance program that involves a rating system for assessing compliance would allow some latitude for mitigation practices that are either unduly problematic or impractical. For example, if a nation decided that limiting debris released during normal operations (guideline number one) was too costly for the next generation of satellites already in production, the score for meeting the standard may be rated as partially compliant (if using the rating system created by the FATF). The country may explicitly decide that the poor rating of partially compliant is an acceptable grade level; however, international peer-monitoring will still apply pressure for increased standards until the country reaches a compliant or largely compliant rating. A peer-review assessment that is not legally bound by a treaty would provide the necessary latitude for nation states to maintain sovereign rights while participating in the process and improving standards as best as practical. Without the latitude to tailor, bend or completely ignore certain standards, nation states will remain in their present state with heels dug in and no forward

movement on adopting compulsory debris mitigation standards because United Nations' members cannot find the necessary legal verbiage that is acceptable to all parties.

As indicated in the example above, the mutual evaluation process is not the ultimate solution to force nations into compliance, if a nation chooses not to participate, or decides to ignore the guidelines, the ratings received on an evaluation will not matter very much. However an assessment system with ratings that could be used to compare nation states' compliance with other nation states would bring offending violations to light. The ease of comparing ratings would increase public awareness of non-compliant countries and would act as the spark that could bring the power of peer-pressure into play.

Feasibility

Implementing a compliance program to strengthen the *United Nations Space Debris Mitigation Guidelines* is a feasible solution. Feasibility is defined as "fits within available resources."[31] There are little associated administrative costs to implementing a compliance program within the international organization. Extra time during plenary meetings would need to be arranged for review and discussion of the mutual evaluations, including the self-report, on-site visit, and any disputed ratings. Additional non-administrative costs, such as sending an evaluator to conduct an on-site visit, would be carried by all member states. Non-administrative cost would include travel costs for the on-site visit to the country under review, travel to the country where the plenary is held (for discussion of results), and time away from the evaluator's day-to-day jobs to produce the evaluation report. The implied cost to member states would include upgrades to current systems that needed improvements in order to meet debris mitigation guidelines.

The cost of implementing the compliance program is feasible because the cost would be spread across all members nearly equally. The cost for a country to send an evaluator abroad would be relatively equalized when the other member jurisdictions send evaluators. Countries that have already implemented some space debris mitigation techniques should actually see less associated costs compared with countries that have not inculcated mitigation practices into space operations. The increase in peer-pressure to meet standards and the nation's pride to receive acceptable ratings on the debris mitigation evaluation would help reduce concerns over possible economic disparities between countries that currently follow mitigation practices and those that do not.

Acceptability

Implementing a compliance program to strengthen the *United Nations Space Debris Mitigation Guidelines* is an acceptable solution. Acceptability is defined as "worth the cost or risk."[32] The literature review revealed that the current levels of space debris are increasing at alarming rates. The experts agree that additional steps need to be taken before certain popular orbits become too hazardous for space based operations or manned flight. Since the achievement of a space debris mitigation treaty does not appear to be a viable solution, other courses of action need to be implemented. A compliance program that includes a verification process is an acceptable, albeit less legally accountable, alternative for the lack of a treaty. The risk of not implementing a system that will decrease the amounts of space debris far outweigh the cost associated with taking an incremental step, such as implementing a mutual evaluation process, to ensure that the space faring industries are adhering to the standards.

Distinguishability

Implementing a compliance program to strengthen the *United Nations Space Debris Mitigation Guidelines* is a distinguishable solution. Distinguishability is defined as “differs significantly from other solutions.”[33] The recommendation of this thesis is distinguishable from the other solutions because it is different from the recommended legal solutions that have been proposed in the literature review. Although a compliance system using mutual evaluation (peer-pressure) has proved successful for financial crimes, the recommendation for a peer-monitoring program has not been addressed in any of the reviewed literature for application toward space debris mitigation.

Completeness

Implementing a compliance program to strengthen the *United Nations Space Debris Mitigation Guidelines* is not a 100 percent complete solution; however, it is a complete recommendation that is a step in the right direction. Completeness is defined as “contain[ing] the critical aspects of solving the problem from start to finish.”[34] Although the compliance program recommended by this thesis does not solve the mitigation of space debris from start to finish, the recommendation is a feasible and acceptable solution.

The distinction between recommending a treaty that is nearly unattainable versus a compliance program that is slightly less than optimal, yet acceptable and feasible, means that a stop-gap solution could be implemented that would extend the projected lifespan for orbits in danger of becoming inoperable. The extended time that the stop-gap solution provides could provide the needed time for the international community to explore ways to achieve the optimal legal solutions recommended by others in the field.

## Summary

The international response to recent debris creating events has been minimal. After the Chinese anti-satellite test, the United Nations passed a set of voluntary guidelines. When the United States conducted a similar operation a year later, the long-term effects were nearly opposite of the Chinese incident. Because the United States adhered to debris mitigation practices, the large amount of debris created during the destruction of the NROL-21 degraded quickly causing less long-term orbital debris. However, no further effort was made to codify the guidelines based on the successful use by the United States. Beyond intentional actions where space organizations can directly control debris mitigation, popular orbits have become alarmingly cluttered causing unintentional space debris incidents, as seen with the accidental collision of the Cosmos and Iridium satellites. Although the United States took measures to address the symptom of the accident, increased satellite tracking, no new measures were implemented to address the core problem of debris mitigation compliance, such as removing defunct satellites out of popular orbits.

The United States has three options to better protect space based national security interests. The first option is to lobby for stronger international laws that would provide better protection to U.S. assets in space; however, the need for freedom of access to space tends to act counter-productively to stronger international controls over space. Therefore, the United States has been reluctant to pursue additional international regulation for mitigating space debris. The second option is to take a stronger stance through force to protect space assets; however, kinetic force in space tends to create more space debris rather than protect assets from debris. The third option is to create a compliance system to

ensure the international community is abiding by the space debris mitigation guidelines. A compliance system based on peer-monitoring and peer-pressure would increase conformity to mitigation measures without infringing on national sovereignty rights for freedom of access to space. In addition a compliance program would not require a formal treaty to be signed. Therefore, increased standards could be implemented without the need for formal agreements on controversial definitions or varying national interests.

An international compliance system for space debris issues could be modeled after elements from the United Nations Third Committee and the FATF. An international space debris peer-monitoring group would have several benefits to countering the increasing space debris threat. The space debris peer-monitoring group would not require a treaty yet would have the benefit of peer-pressure to achieve higher standards. Similar to the mutual evaluation enhanced compliance requirements of the case studies, offending members who do not improve to meet international standards could be subjected to international embarrassment because violations would be posted publicly. Since there is no enforcement mechanism or punishment associated with failing to comply with current space debris mitigation best practices, an international peer-pressure group would produce an incentive to meet higher standards. Other international groups, such as the United Nations Third Committee and FATF have used peer-monitoring as a successful method of improving non-legally binding international standards. The screening criteria used to analyze the two case studies indicate that a space debris compliance program is suitable, feasible, acceptable, distinguishable, and complete; therefore, a similar system should be implemented for space debris mitigation.

The next chapter provides a conclusion and a set of recommendations. Beyond the legal need of translating the United Nations' guidelines on space debris mitigation into a formal, binding, and enforceable agreement, compliance methods should be established to serve as a stop-gap solution that improves conformity with the international standards. In addition to the conclusions, a set of recommendations are offered to address the problem of international compliance with the *United Nations Space Debris Mitigation Guidelines* in order to better protect U.S. national security interests. The IADC focuses on operational issues of space debris and could be expanded to include a national level self-reporting compliance program that is verified through the use of peer monitors.

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[1]James Mackey, "Recent US and Chinese Antisatellite Activities," *Air & Space Power Journal* (22 September 2009): 13.

[2]Ibid.

[3]Ibid.

[4]Amy Butler, "USAF Boosts Space Situational Awareness," *Aviation Week*, 3 July 2009, http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=defense&id=news/AWARE070309.xml&headline=USAF%20Boosts%20Space%20Situational%20Awareness (accessed 6 May 2010).

[5]Theresa Hitchens, "Space Debris: Next Steps," *Safeguarding Space for All: Security and Peaceful Uses–Conference Report 25-26 March 2004*, United Nations Institute for Disarmament Research (UNIDIR), 2005, http://www.unidir.org/pdf/articles/pdf-art2378.pdf (accessed 5 May 2010).

[6]Ibid.

[7]Worldwide Satellite Launches, Collision of Cosmos 2251 and Iridium 33 satellites, published by Phillip Clark/Molniya Space Consultancy on 18 February 2009.

[8]Thierry Sénéchal, Space Debris Pollution: A Convention Proposal; Protocol for a Space Debris Risk and Liability Convention.

[9]Ibid.

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[13]Human Rights: The Pursuit of an Ideal, Thinkquest, http://library.thinkquest.org/C0126065/enfrocement.html (accessed 25 February 2010).

[14]Ibid.

[15]UN Enforcement, 2007, http://www.globalgovernancewatch.org/human_rights/default.asp?id=37&css=print (accessed 25 February 2010).

[16]Ibid.

[17]Ibid.

[18]Robin Cook, "Human Rights–A Priority of Britain's Foreign Policy," *Global Policy Forum*, 28 March 2001, http://www.globalpolicy.org/component/content/article/154/26028.html (accessed 12 May 2010).

[19]Ibid.

[20]UN Enforcement

[21]Ibid.

[22]Ibid.

[23]Jerome B. Elkind, "Application of the International Covenant on Civil and Political Rights in New Zealand," *The American Journal of International Law* 75, no. 1 (January 1981): 172.

[24]Ibid.

[25]Financial Action Task Force, *Mutual Evaluations Programme*, http://www.fatf-gafi.org/pages/0,3417,en_32250379_32236982_1_1_1_1_1,00.html (accessed 12 May 2010).

[26]Financial Action Task Force, *AML/CFT Evaluations and Assessments Handbook for Countries and Assessors* (Paris: Financial Action Task Force, 2009), 12.

[27]Financial Action Task Force, *About the Non-Cooperative Countries and Territories (NCCT) Initiative*, http://www.fatf-gafi.org/document/51/0,3343,en_32250379_32236992_33916403_1_1_1_1,00.html (accessed 12 May 2010).

[28]Ibid.

[29]Headquarters, Department of the Army, Field Manual (FM) 5-0, *Army Planning and Orders Production* (Washington, DC: Government Printing Office, 2005), 2-9.

[30]Ibid.

[31]Ibid.

[32]Ibid.

[33]Ibid.

[34]Ibid., 2-10.

# CHAPTER 5

# CONCLUSIONS AND RECOMMENDATIONS

## Overview

Without intervention, the space environment will soon reach a critical tipping point where space debris is too large of a risk to operate in densely populated orbits. However, to date, no binding authority has been adopted to regulate the mitigation of space debris. The United Nations has only adopted a set of unbinding guidelines because the COPUOS members have not found the acceptable common ground necessary to adopt a formal treaty due to varying national interests and the lack of legally agreed upon definitions. A peer-monitored space debris mitigation compliance program would add the 'check and balance' for the *United Nations Space Debris Mitigation Guidelines* thereby increasing the standards without requiring any additional legally binding treaty or agreement. The increased compliance in space debris mitigation practices at an international level would better protect U.S. national security interests in space.

Analysis was conducted on information found in the literature review to answer three secondary questions: (1) what is the current space debris environment (2) what is the connection between space debris and U.S. national interests and (3) what formal and informal legal structures govern the mitigation of space debris? The current space debris environment is of great concern, yet the international community has been unable to formally require nation states to abide by debris mitigation practices. The connection between space debris and U.S. national security interests is becoming an important tenet; however, concerns over maintaining maximum autonomy for access to space and the potential prohibitive costs associated with space operations if debris mitigation practices

become legally binding preclude the United States from pursuing stronger international requirements. The formal and informal legal structures that govern space debris mitigation have proven to be a good long-term investment in for the survivability of popular orbits. However, the gaps created by unequal national-level standards and the gaps in the debris protection systems (tracking and shielding) have proven that there are significant shortfalls to the current space debris mitigation framework.

## Conclusions

Implementing a compliance program to strengthen the *United Nations Space Debris Mitigation Guidelines* would better protect U.S. national security interests in space. A peer-monitored compliance program would complement the current space debris frameworks while allowing nation states to maintain sovereignty rights for national interests in space. Since a compliance program is not legally binding through a treaty, the flexibility in the system allows nation states to essentially tailor the compliance program to fit within national interests. Since the international community recognizes that space debris is a significant threat, the incentive to develop stronger compliance measures without adopting a treaty is present. Therefore, a peer-monitored space debris mitigation compliance program should receive the backing by a majority of the space faring nations.

### Compliance Measures and Effectiveness: A Space Debris Mitigation Compliance Program

The space debris mitigation compliance program would have diplomatic, information, military, and economic elements of power. The power of each element would be through a series of incentives or reprimands. The conclusion for this thesis is based on the potential effectiveness that each of the five elements of power would bring

to a peer-monitored space debris mitigation compliance program. The five elements of power would enhance current frameworks already established in national and international space industries while allowing for incremental increases in standards and compliance measures to ensure the space environment stays accessible for use.

<u>Diplomatic Element of Power</u>

A compliance program, on the whole, is a form of diplomatic power. The process of implementing a peer-review system will provide the diplomatic element of power that is currently absent for the voluntary measures of the *United Nations Space Debris Mitigation Guidelines.* Since the current guidelines are voluntary, there is no strength behind the recommendations to allow for diplomatic enforcement. A peer-review would bring discrepancies to light and allow for the informal diplomatic power of peer-pressure to be applied for corrective actions. After the implementation of a peer-review program, the continued strengthening of the guidelines by adding new or stricter criteria over time as technology improves or members implement initial mitigation techniques will also enhance the diplomatic power of the compliance program.

Additional diplomatic power through reinforcements or corrective actions could also take place with the use of Memorandums of Understanding. Although, having every nation sign bi-lateral agreements with every other nation is not optimal, Memorandums of Understanding are none-the-less common bi-lateral instruments among international parties when legal requirements or special circumstances are not covered in the standard agreement. For example, two member states may choose to sign a Memorandum of Understanding to abide by the debris mitigation guidelines, adding a redundant but explicit commitment to high standards by both parties, before a bi-lateral space venture is

conducted. Similarly, a country may be required to sign a Memorandum of Understanding to abide by debris mitigation guidelines after demonstrating a severe violation of the rules before the offending nation would be considered a member in good standing again.

A compliance program would bring additional diplomatic forms of power through a carrot and stick approach, such as incentives and punishments. The carrot, (incentive), forms of diplomatic power could be through the release of public statements about the achievements of members in good standing. In addition, an incentive program could be established through the administration of a "seal of approval" for members who exceed debris mitigation criteria. A seal of approval rating could be similar to the energy efficient stickers that appear on eco-friendly kitchen and laundry appliances. Any private organization or government agency that exceeds debris mitigation guidelines could receive the seal of approval thus encouraging others to use their services. The seal of approval system could provide a dual incentive to reduce space debris while boosting marketing sales points for space system services. The stick, (punitive), forms of diplomatic power to take corrective actions would include letters of warning, letters of reprimand, public statements of disapproval, removal of voting privileges or dismissal from the group. Similar to the seal of approval for exceptional debris mitigation standards, a blacklist could be created for private organizations or jurisdictions who fail to comply with the established international standards.

### Information Element of Power

The information element of power could act as a carrot and stick approach for an international compliance program to mitigate space debris. Cooperative exchanges of

information could be a carrot for compliance with debris mitigation practices. Also withholding information could act as a stick. Information as an element of power could come in a variety of forms; therefore, the carrot or stick for each type of information exchanged or withheld would be different. For example, if a country were to be blacklisted for sever violations of space debris mitigation, then other space faring nations may choose to withhold any requests for commercial or civil satellite images that the violating country had requested. Of course, the type of information, access from other sources, and the need for certain space related information for safe conduct (air traffic control via Global Positioning System information) would have to be considered; however, information in the current digital age has become increasingly important and would be a powerful incentive to comply with space debris mitigation practices.

Military Element of Power

Since the IADC does not have a military element, no international power will be available to act as a carrot or stick through military means. However, since space based operations have close ties to military operations, nation states could apply military power as an incentive or putative measure for an international compliance program. For example, if a member nation requires assistance to implement debris mitigation techniques, an incentive (carrot) could be a partner nation with military forces available to provide training or funding for assistance on joint ventures projects. Since any direct hostile action would fall under domestic policies for protection, the use of a military power (stick) would be applicable in the background of any international space agreement. Military actions as corrective actions for hostile acts involving space debris could include attacks against ground based space assets or non-kinetic disruption

(jamming) by military forces. For international purposes, military uses could include, at the extreme, the denial of access space for repeat offenders that create significant quantities of debris or for actions that have undertones of indirect hostile intentions.

### Economic Element of Power

The economic element of power would emerge as a second carrot and stick that naturally occurs from the use of diplomatic and information elements of power. Every action or non-action taken to mitigate the creation of space debris will impact the economic prosperity of member nations. For example, a seal of approval rating discussed as a diplomatic power above, could also serve as an economic power to boost sales for space system services that exceed debris mitigation guidelines. Similarly, an economic benefit may be realized by nations that have already implemented debris mitigation techniques because they will not have to invest in significant policies and procedures changes in order to meet the compliance standards. Since compliance would bring the mitigation standards to an even playing field, the concerns over economic imbalances between nations or private organizations that follow debris mitigation guidelines and those that do not would be reduced.

Closely tied to the economic incentive carrots, the compliance program could use economic corrective action sticks. For example, by withholding the seal of approval organizations would lose business because of poor debris mitigation practices. Although the initial costs to implement debris mitigation techniques would have an associated cost, the company would gain benefit from maintaining a customer base that will use the services. Whether in the form of launch facilities, launching platforms, or system

construction, the long-term benefit of maintaining an operational orbit will far outweigh the immediate need to save money by opting out of debris mitigation techniques.

## Recommendations

The literature review indicated that the current formal and informal space debris mitigation structures did not have the ability to effectively enforce the policies and guidelines that underpin the mitigation of space debris. The analysis of the two case studies on international organizations with compliance programs indicates that a similar system could be established for the space debris mitigation guidelines. The recommendation of this thesis is to establish a peer-monitored space debris mitigation compliance program.

### Where to Establish a Space Debris Compliance Program?

In order to determine where to establish a space debris compliance program, a review of the international organization's structures was conducted. The structures of the United Nations Third Committee and the FATF were considered in relation to the United Nations' COPUOS structure. Based on the similarities and differences, a recommendation is made for the international organization that could most likely implement a successful peer-monitored space debris mitigation compliance program.

#### Structure: The United Nations Social, Humanitarian and Cultural Affairs Committee

The United Nations Third Committee consists of all United Nations' members, which comprises of approximately 192 member states and permanent observers. Elected during yearly General Assembly sessions, the Committee is led by a chairman, three vice

chairmen, and a rapporteur, a person appointed to investigate an issue and report back to the committee.

The historical timeline of the Third Committee's development of agreements for human rights is similar to the timeline of the COPUOS's development of the space treaty and conventions. In 1945, the "Charter of the United Nations made reference to human rights without a clear definition; it wasn't until 1948 when the *Universal Declaration of Human Rights* delineated the basic core concepts of human rights."[1] Similar to the establishment of the space treaty in the late 1960s, the United Nations passed the 1966 *International Covenant on Civil and Political Rights* and the 1966 *International Covenant on Economic, Social and Cultural Rights*. Similar to the unwelcomed efforts by space debris groups in the 1980s and 90s to gain some traction on a legally binding space debris convention in COPUOS, it was only after the end of the Cold War[2] in the late 1980s that human rights issues gained traction among the member states of the United Nations Human Rights Committee. Until the end of the Cold War, there was a strict line in the sand among Western and Socialist members of the United Nations Third Committee for how to achieve human rights. Socialist countries saw human rights protected under social welfare programs by the government, where western countries saw human rights in political and civil freedoms such free speech, thus the reason for two human rights covenants. Also similar to the space debris issue, the human rights issue is "paid much rhetoric, but there are no resources or respect for this issue with major international organizations . . . [and] there is a lack of international commitment."[3]

Since both the Third Committee and COPUOS are United Nation Committees, both have similar international membership groups and historical timeline for passing

international agreements. The fact that the Third Committee has a self-reporting and a self-reporting with interview compliance program with the two sub-committees proves that a compliance program is feasible within the COPUOS. However, the two organizations have a wide scope within the respective purviews. For example, COPUOS is responsible for all international space facets, not just the subset of space debris issues. In addition, the bureaucracy involved in gaining consensus from all member nations has been problematic and inefficient when forward progress is required.

Structure: The Financial Action Task Force

The FATF is an inter-governmental body established by the G-7 Summit in 1989. The FATF is comprised of 34 member countries, organizations and observer countries.[4] Because the FATF has limited its membership to a small but globally representative group of jurisdictions, seven other regional bodies, FSRBs, have been established throughout the world so that non-FATF members could belong to a similar organization. The structure of the FATF includes a president and vice president, elected for a one-year period from a member jurisdiction, and a secretariat that provides administrative support to the organization. Similarity in lines of effort among the regional bodies is achieved because jurisdictions who are a member of one regional body or FATF can be observers, or in rare cases full members, of the other regional bodies allowing for cross-pollination of experience and philosophies.

The seven international organizations follow the same recommendations and have replicated the compliance programs established by the FATF. The drawback to having eight autonomous but closely connected organizations enforce the same set of recommendations is the various interpretations and operational definitions among the

regional bodies depending on the circumstances of the region. For example, the regional body established for jurisdictions in the European region, which are legally bound by European Union regulation for terrorism and financial crime laws, will have slightly different interpretations for small segments of the forty plus nine recommendations compared to the interpretation by regional bodies for South America or Africa.

Depending on the maturity, organizational strength, and operational rules of the regional body, the mutual evaluation reports may or may not be posted publicly. In addition, because the personnel on each evaluation team will vary with every mutual evaluation, the quality and consistency of mutual evaluation report could vary. For example, each evaluator must have a high level of field expertise; knowledge of recommendation criteria; and knowledge of different, yet acceptable, ways that a jurisdiction can meet the criteria, in order to correctly grade a country; however, there is often a low supply of experts. Additionally, smaller jurisdictions cannot always afford to release an expert for the on-site evaluation process, the follow-on review, the time needed to write the report, and the additional time and expense required to send the expert to the plenary discussion. The regional bodies that have been established for several years will often have a larger pool of experts and more standardized practices in place that newer regional bodies are still developing.

Although a compliance program similar in structure to the FATF mutual evaluation process is recommended for the space debris compliance program, the structure of the FATF and associated regional bodies is not a recommended model for space debris mitigation. It would be better to maintain a compliance program, for standardization and fairness in only one international body instead of spreading it among

several organizations. In addition, the complications seen among the FATF and FSRB organizations, such as limited number of experts in each organization and various policies for publicly releasing reports, would be better organized and consolidated if only one international body, instead of eight, were responsible for implementing the compliance program.

Recommended Structure: A Space Debris Mitigation Compliance Program

The recommendation of this thesis is to use an international organization with an operational-level focus, such as the IADC. The IADC, founded in 1993, "is an international forum of governmental bodies for the coordination of activities related to the issues of man-made and natural debris in space."[5] Appendix C contains the member agencies of the IADC. On 15 October 2002, the Committee published a set of guidelines that, in conjunction with the U.S. space debris mitigation policy, laid the foundation for the *United Nations Space Debris Mitigation Guidelines*.[6] Since the United Nations COPUOS is the forum for developing a broad range of international space law, not just space debris mitigation the IADC appears to be the optimal organization to implement a space debris compliance program. In addition, since the IADC is a single cohesive international body that has not limited membership causing the need for regional bodies to form as the FATF has done, or had to split into sub-committees due to Cold War political views as the United Nations Third Committee has done, the organization is better suited to implement a comprehensive compliance program.

The COPUOS, in conjunction with the IADC could develop a set of criterion for each of the United Nations' space debris guidelines. The four "most promising"

techniques for standardization, (venting residual fuel and pressurants from discarded rocket bodies; boosting satellites from geosynchronous Earth orbit into disposal orbits; de-orbiting spent hardware; and reducing operational debris), identified by the AIAA[7] could be the natural starting list of criterion for the *United Nations Space Debris Mitigation Guidelines*. As the formal body to set international space law, COPUOS would be the regulatory authority that establishes the standards, while the IADC would be the operational-level implementing authority that contains the space debris expertise to assess member states and apply corrective measures.

For example, the criterion for guideline number five, minimize potential for post-mission break-ups resulting from stored energy, could include venting residual fuel and pressurants from discarded rocket bodies, one of the "most promising" techniques.[8] In order for a country to be rated compliant with guideline number five, it must have designed space based systems that vent residual fuel and pressurants from used rocket bodies. A country with a largely compliant rating may be able to vent fuel from low Earth orbit systems and geosynchronous orbits but not from highly elliptical orbits. A country with a partially compliant rating may have a policy in place, but has not yet designed space systems to vent residual fuel. A country with a non-compliant rating would not have a national policy in place requiring space systems to vent residual fuel. The IADC would have procedures in place to take corrective measures for member states who receive poor ratings (partially or non-compliant ratings) while international peer-pressure would likely be applied against the jurisdiction to influence increased compliance.

In addition to the 'name and shame' program for violators of international standards, another element that the international space debris peer-pressure group could

implement would be a seal of approval for members who meet space debris mitigation standards. Instead of the concerns over a potential economic gain for non-compliant countries seen within the current voluntary compliance system, the benefit would be flipped so that an economic benefit would be seen for agencies that comply with standards and achieve a seal of approval. The seal of approval system could be selection criteria for winning contracts to launch or build satellites while marginalizing organizations that do not maintain standards.

The assurance that member nations are in compliance with international space debris mitigation issues would be beneficial to all space faring nations concerned with the growing threat of operational debris. Although some nations and private organizations may claim the need to protect technology secrets, the mutual evaluation (peer-monitored) process could be implemented within specific space debris mitigation technique parameters so that national security issues and proprietary technology is not compromised. For example, using criterion number five, as in the example above, to minimize potential for post-mission break-ups resulting from stored energy, the on-site visit may include a meeting with the government and private organizations involved in space launches to discuss how the organizations vent residual fuel and pressurants from discarded rocket bodies. The organizations could demonstrate compliance either through showing or describing the venting system, or if the technology is proprietary, then producing official documents or scientific reports that show that discarded rocket bodies routinely vent fuel upon completion of the mission.

On-site visits that last only a week or two will not be able cover 100 percent of country’s space program to verify that debris mitigation practices are actually

incorporated into every aspect of a country's space industry; however, the visit serves as a 'check and balance' to spot-check or clarify issues from the self-reported assessment submitted by the jurisdiction. Most of the on-site visit will be conducted through discussions and meetings arranged with various domestic space industry members. For example, the on-site assessment would meet with the jurisdiction's regulatory body to gain an understanding of nuances or intent of the national-level space debris mitigation policies then follow-on visits with space industry specialists would include discussions on knowledge of current policies, effectiveness of national policies, incorporation of policies into company contracts and standards, and detailed descriptions on how policies are being translated into actionable items.

Although the recommended peer-monitored compliance program would not obligate nations to comply or be a party to mutual evaluations, the research has shown that peer-pressure and international opinion do influence stronger compliance with international standards. If a nation, or private organization, were to categorically refuse to comply with space debris mitigation, there is little to stop the entity from creating large amounts of long-lasting debris; however, if a majority of international community comply, the negative backlash against the outlier would be significant. By having a compliance program, albeit less legally binding than a treaty, a series of informal enforcement measures would be available that is not currently present in the voluntary space debris guidelines.

## Summary

A peer-monitored space debris mitigation compliance program implemented within the IADC would provide better protection of U.S. national security interests in

space. Recent debris creating events have contributed to the congestion of space debris in popular orbits. The tipping point where viable operational orbits become inaccessible due to space debris is only a few major collisions away. The international attitude towards stronger space debris mitigation regulations has not been productive because the fear of excessive costs, the fear of reduced access to space, the disagreement over definitions and terminology, and various national interests has taken a priority. A peer-monitored compliance program would be able increase standards without infringing on the national sovereignty rights that have blocked diplomatic progress towards a space debris treaty.

The IADC has the necessary operational focus and expertise to implement a mutual evaluation compliance program for space debris mitigation. The analysis of similar compliance programs for international organizations has proven to be suitable, feasible, acceptable, distinguishable and complete. The conclusions show that a compliance program would have diplomatic, information, military (through domestic policies), and economic powers. The IADC would be the optimal organization to implement a space debris mitigation compliance program that would better protect U.S. national security interests in space.

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[1]C. Eduardo Vargas, Human Rights and their lack of Enforcement, Intersections International, 5 May 2008, http://www.intersectionsinternational.org/node/170 (accessed 25 February 2010).

[2]Ibid.

[3]Ibid.

[4]The Financial Action Task Force, About FATF, http://www.fatf-gafi.org/pages/0,3417,en_32250379_32236836_1_1_1_1_1,00.html (accessed 25 February 2010).

[5]Inter-Agency Space Debris Coordination Committee (IADC), "Space Debris Mitigation Guidelines, IADC-02-01," September 2007, http://www.orbital debris.jsc.nasa.gov/library/IADC_Mitigation_Guidelines_Rev_1_Sep07.pdf (accessed 31 March 2010).

[6]Ibid.

[7]American Institute on Aeronautics and Astronautics (AIAA), *Orbital Debris Mitigation Techniques: Technical, Economic, and Legal Aspects* (Washington, DC: AIAA, 1 January 1992).

[8]Ibid.

## GLOSSARY

Agreements. The term “agreement” can have a generic and a specific meaning. It also has acquired a special meaning in the law of regional economic integration.

(a) Agreement as a generic term: The 1969 Vienna Convention on the Law of Treaties employs the term “international agreement” in its broadest sense. On the one hand, it defines treaties as “international agreements” with certain characteristics. On the other hand, it employs the term “international agreements” for instruments, which do not meet its definition of “treaty”. Its Art.3 refers also to “international agreements not in written form”. Although such oral agreements may be rare, they can have the same binding force as treaties, depending on the intention of the parties. An example of an oral agreement might be a promise made by the Minister of Foreign Affairs of one State to his counterpart of another State. The term “international agreement” in its generic sense consequently embraces the widest range of international instruments.

(b) Agreement as a particular term: “Agreements” are usually less formal and deal with a narrower range of subject-matter than “treaties”. There is a general tendency to apply the term “agreement” to bilateral or restricted multilateral treaties. It is employed especially for instruments of a technical or administrative character, which are signed by the representatives of government departments, but are not subject to ratification. Typical agreements deal with matters of economic, cultural, scientific and technical cooperation. Agreements also frequently deal with financial matters, such as avoidance of double taxation, investment guarantees or financial assistance. The UN and other international organizations regularly conclude agreements with the host country to an international conference or to a session of a representative organ of the Organization. Especially in international economic law, the term “agreement” is also used as a title for broad multilateral agreements (e.g. the commodity agreements). The use of the term “agreement” slowly developed in the first decades of this century. Nowadays by far the majority of international instruments are designated as agreements.

(c) Agreements in regional integration schemes: Regional integration schemes are based on general framework treaties with constitutional character. International instruments which amend this framework at a later stage (e.g. accessions, revisions) are also designated as “treaties”. Instruments that are concluded within the framework of the constitutional treaty or by the organs of the regional organization are usually referred to as “agreements”, in order to distinguish them from the constitutional treaty. For example, whereas the Treaty of Rome of 1957 serves as a quasi-constitution of the European Community, treaties concluded by the EC with other nations are usually designated as agreements. Also, the Latin American Integration Association (LAIA) was established by the Treaty of

Montevideo of 1980, but the subregional instruments entered into under its framework are called agreements.[1]

Conventions. The term "convention" again can have both a generic and a specific meaning.

(a) Convention as a generic term: Art.38 (1) (a) of the Statute of the International Court of Justice refers to "international conventions, whether general or particular" as a source of law, apart from international customary rules and general principles of international law and - as a secondary source - judicial decisions and the teachings of the most highly qualified publicists. This generic use of the term "convention" embraces all international agreements, in the same way as does the generic term "treaty". Black letter law is also regularly referred to as "conventional law", in order to distinguish it from the other sources of international law, such as customary law or the general principles of international law. The generic term "convention" thus is synonymous with the generic term "treaty".

(b) Convention as a specific term: Whereas in the last century the term "convention" was regularly employed for bilateral agreements, it now is generally used for formal multilateral treaties with a broad number of parties. Conventions are normally open for participation by the international community as a whole, or by a large number of states. Usually the instruments negotiated under the auspices of an international organization are entitled conventions (e.g. Convention on Biological Diversity of 1992, United Nations Convention on the Law of the Sea of 1982, Vienna Convention on the Law of Treaties of 1969). The same holds true for instruments adopted by an organ of an international organization (e.g. the 1951 ILO Convention concerning Equal Remuneration for Men and Women Workers for Work of Equal Value, adopted by the International Labour Conference or the 1989 Convention on the Rights of the Child, adopted by the General Assembly of the UN).[2]

Protocols . The term "protocol" is used for agreements less formal than those entitled "treaty" or "convention." The term could be used to cover the following kinds of instruments:

(a) A Protocol of Signature is an instrument subsidiary to a treaty, and drawn up by the same parties. Such a Protocol deals with ancillary matters such as the interpretation of particular clauses of the treaty, those formal clauses not inserted in the treaty, or the regulation of technical matters. Ratification of the treaty will normally ipso facto involve ratification of such a Protocol.

(b) An Optional Protocol to a Treaty is an instrument that establishes additional rights and obligations to a treaty. It is usually adopted on the same day, but is of independent character and subject to independent ratification. Such protocols enable certain parties of the treaty to establish among themselves a framework of

obligations which reach further than the general treaty and to which not all parties of the general treaty consent, creating a “two-tier system”. The Optional Protocol to the International Covenant on Civil and Political Rights of 1966 is a well-known example.

(c) A Protocol based on a Framework Treaty is an instrument with specific substantive obligations that implements the general objectives of a previous framework or umbrella convention. Such protocols ensure a more simplified and accelerated treaty-making process and have been used particularly in the field of international environmental law. An example is the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer adopted on the basis of Arts.2 and 8 of the 1985 Vienna Convention for the Protection of the Ozone Layer.

(d) A Protocol to amend is an instrument that contains provisions that amend one or various former treaties, such as the Protocol of 1946 amending the Agreements, Conventions and Protocols on Narcotic Drugs.

(e) A Protocol as a supplementary treaty is an instrument which contains supplementary provisions to a previous treaty, e.g. the 1967 Protocol relating to the Status of Refugees to the 1951 Convention relating to the Status of Refugees.

(f) A Proces-Verbal is an instrument that contains a record of certain understandings arrived at by the contracting parties.[3]

Treaties. The term “treaty” can be used as a common generic term or as a particular term which indicates an instrument with certain characteristics.

(a) Treaty as a generic term: The term “treaty” has regularly been used as a generic term embracing all instruments binding at international law concluded between international entities, regardless of their formal designation. Both the 1969 Vienna Convention and the 1986 Vienna Convention confirm this generic use of the term “treaty”. The 1969 Vienna Convention defines a treaty as “an international agreement concluded between States in written form and governed by international law, whether embodied in a single instrument or in two or more related instruments and whatever its particular designation”. The 1986 Vienna Convention extends the definition of treaties to include international agreements involving international organizations as parties. In order to speak of a “treaty” in the generic sense, an instrument has to meet various criteria. First of all, it has to be a binding instrument, which means that the contracting parties intended to create legal rights and duties. Secondly, the instrument must be concluded by states or international organizations with treaty-making power. Thirdly, it has to be governed by international law. Finally the engagement has to be in writing. Even before the 1969 Vienna Convention on the Law of Treaties, the word “treaty” in its generic sense had been generally reserved for engagements concluded in written form.

(b) Treaty as a specific term: There are no consistent rules when state practice employs the terms "treaty" as a title for an international instrument. Usually the term "treaty" is reserved for matters of some gravity that require more solemn agreements. Their signatures are usually sealed and they normally require ratification. Typical examples of international instruments designated as "treaties" are Peace Treaties, Border Treaties, Delimitation Treaties, Extradition Treaties and Treaties of Friendship, Commerce and Cooperation. The use of the term "treaty" for international instruments has considerably declined in the last decades in favor of other terms.[4]

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[1]United Nations, "Definition of Key Terms," http://treaties.un.org/Pages/Overview.aspx?path=overview/definition/page1_en.xml (accessed 4 April 2010).

[2]Ibid.

[3]Ibid.

[4]Ibid.

APPENDIX A

THREATENED SATELLITES FROM FENG YUN-1C ASAT

Table of threatened satellites[1]

| **Name of Satellite, Alternate Names** | **Country of Operator/ Owner** | **Users** | **Purpose** |
|---|---|---|---|
| IRS-P6 | India | Government | Remote Sensing |
| Met Op-A<br>Met Op Sat | Multinational | Government/ Civil | Earth Science/Meteorology |
| Cute-1 Cubical Titech Eng Sat,<br>Oscar 55 | Japan | Civil | Technology Development |
| Cubesat XI-IV<br>Oscar 57 | Japan | Civil | Technology Development |
| Spot 2 | France/Belgium/ Sweden | Commercial | Earth Observation |
| Spot 4 | France/Belgium/ Sweden | Commercial | Earth Observation |
| Feng Yun-3A<br>(FY-3A) | China (PR) | Government | Earth Science |
| MOST | Canada | Civil | Astrophysics |
| DMSP SD-3 F15, USA 147 | USA | Military | Earth Science/Meteorology |
| DMSP 5D-2 F14, USA 131 | USA | Military | Earth Science/Meteorology |
| DMSP 3D-3 F16, USA 191 | USA | Military | Earth Science/Meteorology |
| DMSP SD-3 F16, USA 172 | USA | Military | Earth Science/Meteorology |
| DMSP 5D-2 F13, USA 109 | USA | Military | Earth Science |
| NOAA-18 (NOAA-N, COSPAS-SARSAT) | USA | Government | Meteorology |
| NOAA-16<br>(NOAA-L) | USA | Government | Earth Science/Meteorology |
| Feng Yun-1 D (FY-1 D) | China (PR) | Government | Earth Science |

[1]James Mackey, “Recent US and Chinese Antisatellite Activities,” *Air & Space Power Journal* (22 September 2009): 13. Referencing table retrieved from Union of Concerned Scientists, “UCS Satellite Database,” 6 October 2008, http://www/ucsusa/org/nuclearweapons_and_globalsecurity/space weapons/technical issues/ucs-satellite-database.html.

APPENDIX B

UNITED NATIONS COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE:

MEMBERS[1]

| | | |
|---|---|---|
| Albania | Germany | Poland |
| Algeria | Greece | Portugal |
| Argentina | India | Republic of Korea |
| Australia | Indonesia | Romania |
| Austria | Iran | the Russian Federation |
| Belgium | Iraq | Saudi Arabia |
| Benin | Italy | Senegal |
| Bolivia | Japan | Sierra Leone |
| Brazil | Kazakhstan | Slovakia |
| Bulgaria | Kenya | South Africa |
| Burkina Faso | Lebanon | Spain |
| Cameroon | Libyan Arab Jamahiriya | Sudan |
| Canada | Malaysia | Sweden |
| Chad | Mexico | Switzerland |
| Chile | Mongolia | Syrian Arab Republic |
| China | Morocco | Thailand |
| Colombia | Netherlands | Turkey |
| Cuba | Nicaragua | the United Kingdom of Great Britain and Northern Ireland |
| Czech Republic | Niger | the United States of America |
| Ecuador | Nigeria | Ukraine |
| Egypt | Pakistan | Uruguay |
| France | Peru | Venezuela |
| Hungary | Philippines | Vietnam |

Note: States that rotate seats every three years: Greece and Turkey.

[1]United Nations, "United Nations Committee on the Peaceful Uses of Outer Space: Members," United Nations Office for Outer Space Affairs, http://www.oosa.un vienna.org/oosa/COPUOS/members.html (accessed 21 November 2009).

## APPENDIX C

## THE INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE

The Inter-Agency Space Debris Coordination Committee (IADC) member agencies[1] include:

1. ASI (Agenzia Spaziale Italiana)
2. BNSC (British National Space Centre)
3. CNES (Centre National d'Etudes Spatiales)
4. CNSA (China National Space Administration)
5. DLR (German Aerospace Center)
6. ESA (European Space Agency)
7. ISRO (Indian Space Research Organisation)
8. JAXA (Japan Aerospace Exploration Agency)
9. NASA (National Aeronautics and Space Administration)
10. NSAU (National Space Agency of Ukraine)
11. ROSCOSMOS (Russian Federal Space Agency)

[1]Inter-Agency Space Debris Coordination Committee, "Welcome to the Inter-Agency Space Debris Coordination Committee," 2009, http://www.iadc-online.org/index.cgi (accessed 21 November 2009).

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